PB81-212482

Disposal of Flue Gas Desulfurization Wastes EPA Shawnee Field Evaluation

Aerospace Corp.
Los Angeles, CA

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Jun 81

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA 600/7-81-103
June 1981

PB81-212482

DISPOSAL OF FLUE GAS DESULFURIZATION WASTES:
EPA SHAWNEE FIELD EVALUATION
FINAL REPORT

January 1981

by

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Contract No. 68-02-2633

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Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, D.C. 20460

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IERL-RTP-1199

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/7-81-103

2.
ORD Report

3. RECIPIENT'S ACCESSION NO.
PB81-212482

4. TITLE AND SUBTITLE
Disposal of Flue Gas Desulfurization Wastes: EPA Shawnee Field Evaluation--Final Report

5. REPORT DATE
June 1981

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
P.R. Hurt, P.P. Leo, J. Rossoff, and J.R. Witz

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
The Aerospace Corporation
P.O. Box 92957
Los Angeles, California 90009

10. PROGRAM ELEMENT NO.
1NE624A

11. CONTRACT/GRANT NO.
68-02-2633

12. SPONSORING AGENCY NAME AND ADDRESS
EPA, Office of Research and Development
Industrial Environmental Research Laboratory
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED
Final; 9/74 - 9/80

14. SPONSORING AGENCY CODE
EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer is Julian W. Jones, Mail Drop 61, 919/541-2489. EPA-600/7-80-011, 7-78-024, and 2-76-070 are related reports.

16. ABSTRACT

The report summarizes results of the flue gas desulfurization (FGD) waste disposal field evaluation project sponsored by EPA at TVA's Shawnee steam plant, Paducah, KY. This pilot-scale project, initiated in 1974 and completed in September 1980, evaluated methods and costs for disposing of wastes produced from wet non-regenerable scrubbing of SO2 from coal-fired utility-boiler flue gases. The environmental effects of various disposal techniques were studied, including evaluations of untreated, chemically treated, and oxidized wastes utilizing lime or limestone scrubber absorbents. Because water quality and land reclamation are of principal interest, leachate, supernate, runoff, and ground water were analyzed, and physical properties of the wastes were evaluated. No measurable effect on ground water quality at the disposal site was detected during the program. Chemical treatment and underdrainage of untreated waste yielded structurally sound materials. Cost-effective and environmentally sound disposal methods for FGD wastes and slurried gypsum appear to be ponding with underdrainage and chemical treatment/landfilling of the FGD waste. Disposal costs for these methods range from about 0.8 to 1.5 mills/kWh, based on a high-sulfur (e.g., 3%) coal application.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Coal	Pollution Control	13B	21D
Waste Disposal	Utilities	Stationary Sources		
Desulfurization	Calcium Oxides		07A, 07D	
Flue Gases	Calcium Carbonates		21B	
Gas Scrubbing	Ground Water		13H	08H
Sulfur Oxides	Gypsum		07B	08G

18. DISTRIBUTION STATEMENT
Release to Public

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
289

22. PRICE

EPA Form 2220-1 (9-73)

ABSTRACT

This report summarizes the results of the Flue Gas Desulfurization (FGD) Waste Disposal Field Evaluation Project sponsored by the U.S. Environmental Protection Agency at the Tennessee Valley Authority Shawnee Steam Plant, Paducah, Kentucky. This pilot scale project, which was initiated in 1974 and completed in September 1980, evaluated methods and costs for disposing of wastes produced from wet, nonregenerable scrubbing of sulfur dioxide from coal-fired utility boiler flue gases. The environmental effects of various disposal techniques were studied, including evaluations of untreated, chemically treated, and oxidized wastes utilizing lime or limestone scrubber absorbents.

Because water quality and land reclamation are of principal interest, analyses of leachate, supernate, runoff, and ground water were conducted, and physical properties of the wastes were evaluated. No measurable effect on the ground water quality at the disposal site was detected during the course of the program. Chemical treatment and underdrainage of untreated waste yielded structually sound materials. Cost-effective and environmentally sound disposal methods for FGD waste and slurried gypsum appear to be ponding with underdrainage and chemical treatment/landfilling of the FGD waste. Disposal costs for these methods range from about 0.8 to 1.5 mills/kWh, based on a high-sulfur (e.g., 3%) coal application.

This report was submitted in fulfillment of Contract No. 68-02-2633 by The Aerospace Corporation under the sponsorship of the U. S. Environmental Protection Agency. This report covers the period from September 1974 to September 1980, and work completed as of September 1980.

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CONVERSION TABLE

To Convert from English Units	To Metric Units	Multiply by
Acres	Square Meters	4047
Acre-Feet	Cubic Meters	1234
Btu	Joules	1054
Btu per Hour	Watts	0.2929
Cubic Feet	Cubic Meters	0.02832
Cubic Yards	Cubic Meters	0.7646
Feet	Meters	0.3048
Feet per Minute	Meters per Second	0.005080
Feet per Second	Meters per Second	0.3048
Foot-Pounds	Joules	1.356
Foot-Pounds per Minute	Watts	0.02260
Gallons	Cubic Meters	0.003785
Gallons per Minute	Cubic Meters per Second	0.2271
Horsepower (Electric)	Watts	746.0
Inches	Meters	0.02540
Miles per Hour	Meters per Second	0.4470
Miles	Meters	1609
Pounds	Kilograms	0.4536
Pounds	Newtons	4.448
Pounds per Cubic Foot	Kilograms per Cubic Meter	16.02
Pounds per Square Inch	Newtons Per Square Meter	7031
Square Feet	Square Meters	0.09290
Square Yards	Square Meters	0.8361
Tons (Short)	Kilograms	907.2
Yards	Meters	0.9144

ACKNOWLEDGMENTS

The results reported in this document reflect the cooperation and valuable contributions of individuals from a number of organizations associated with this project. In particular, the authors wish to acknowledge Julian W. Jones and Michael C. Osborne, the U.S. Environmental Protection Agency (EPA) Flue Gas Desulfurization Waste Disposal Project Officers, whose management and technical guidance have been especially helpful, and John Williams, the EPA Shawnee Project Officer, for his continuing assistance in conducting project activities at the evaluation site.

The following personnel also have been most helpful in providing technical assistance on the work covered by this report:

The Aerospace Corporation

K. A. Douglas
W. M. Graven
W. F. Reddall, III
P. A. Riley
J. N. Sagara
J. Velasquez

Tennessee Valley Authority (TVA)

D. G. Carpenter
H. K. Caylor
J. J. Cummings
C. Gottschalk

SECTION 1

INTRODUCTION

This report summarizes activities and results of the Environmental Protection Agency (EPA) Shawnee Flue Gas Desulfurization (FGD) Field Disposal Evaluation Project. This project, initiated in September 1974, was designed to evaluate various ponding and landfill alternatives and to develop cost estimates for the disposal of by-products from wet, nonregenerable scrubbing of sulfur dioxide (SO_2) from coal-fired utility boiler flue gases. The environmental effects of various disposal techniques, as well as scrubber reagent, operations, weather, and field operating procedures were assessed with the goal of determining environmentally sound disposal methods. Water quality and land reclamation are of principal interest and, to that end, periodic sampling, analyses, and assessments were conducted of leachate, supernate, runoff, ground water, and soil and waste cores. The Aerospace Corporation was responsible for the project planning, coordination, selected water and solids analysis, assessment and evaluation of the various disposal methods, and reporting. Site construction, maintenance, coring, water sampling, and routine water analyses were performed by the Tennesee Valley Authority (TVA). The technical effort described in this report was completed in September 1980.

Ten field sites were evaluated in this project, which is located at the TVA Shawnee Steam Plant near Paducah, Kentucky. Of the ten sites, eight of these ranged in size up to 6000 ft^2 with a waste depth of 3 ft to 4 ft, while two are surface disposal sites at about 2000 ft^2. Waste materials for this project were produced by two scrubber systems. Using lime or limestone slurries as the SO_2 absorbent, each of the scrubbers, a UOP, Inc., turbulent contact absorber (TCA), and a Chemico, Inc., venturi spray tower (VST) treated a flue gas slipstream equivalent to 10 MW from one of the boilers. Waste produced by both scrubbers were evaluated. The disposal techniques consisted of the following: (a) untreated waste ponding, (b) chemical treatment and landfilling, (c) chemical treatment and ponding, (d) calcium sulfite oxidation to gypsum and subsequent disposal, and (e) untreated waste ponding with underdrainage. Figure 1 illustrates the relationship of the FGD waste to the disposal alternatives that were evaluated at Shawnee. This project has provided a broad data base for the evaluation of the control of SO_2 scrubber wastes by combining analyses of results from field disposal operation and laboratory tests.

This is the final report to be issued on this project. The first three reports (Refs. 1 through 3) discussed the results obtained on the project from September 1974 through June 1976. This report contains the data and results of analyses generated from September 1974 through September 1980.

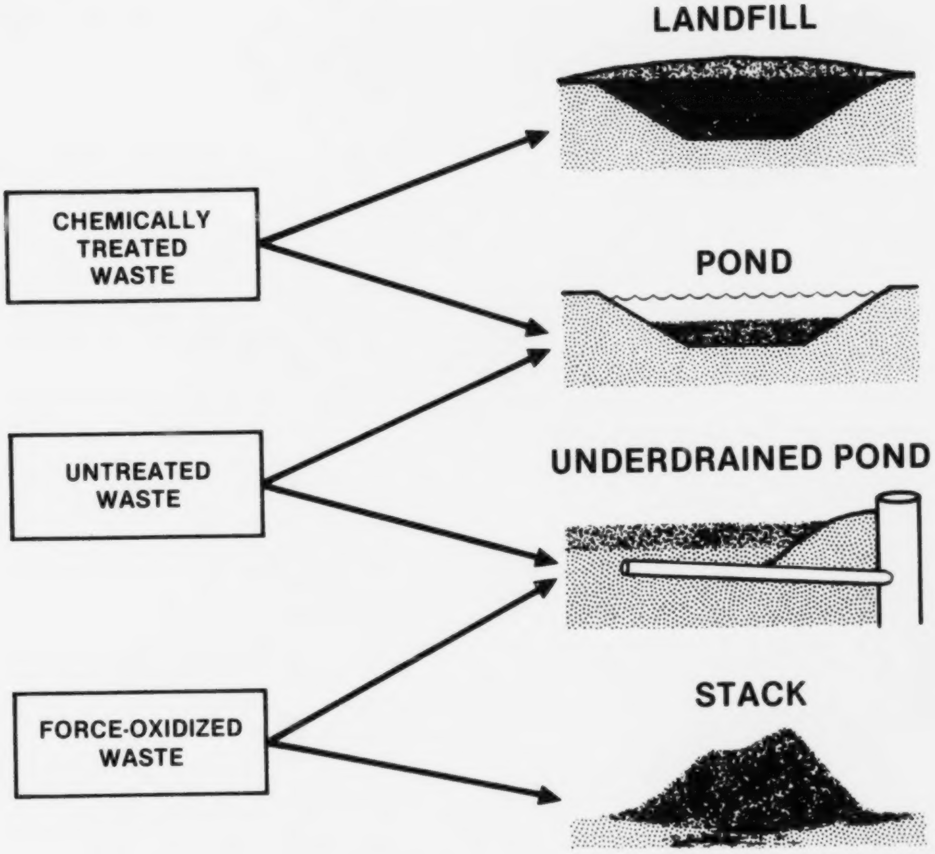

LANDFILL
CHEMICALLY TREATED WASTE
POND
UNTREATED WASTE
UNDERDRAINED POND
FORCE-OXIDIZED WASTE
STACK

Figure 1. FGD waste disposal alternatives

The effort reported on in this document is part of a broad range of FGD waste disposal study activities by EPA, the results of which have been described in other Aerospace reports (Refs. 4 through 6). The most recent of these reports (Ref. 6) provides the results of the chemical characterization and physical properties analyses for untreated and chemically treated wastes from 13 different scrubbers at Eastern and Western power plants using lime, limestone, or double-alkali absorbers. The data given in this document are oriented toward the specific activities at the TVA Shawnee Plant, but where appropriate references are made to relate this work to the general field of FGD waste disposal.

SECTION 2

FINDINGS

The results obtained from the FGD waste disposal evaluation project have indicated several cost-effective methods that physically stabilize the wastes, prevent water pollution, and permit site reclamation. These methods include chemical treatment, underdrainage of untreated waste, and surface drainage of ponded gypsum.

The results have shown the following:

1. Chemical treatment reduces the coefficient of permeability by at least one order of magnitude and reduces the initial concentration of major species in leachate by about 50%. Chemical treatment converts the waste into a structural material, is amenable to subgrade or above-grade landfilling, and can be contoured to promote the runoff of rainwater. Typically, chemical treatment did not appreciably reduce the concentration of trace elements in the leachate. However, of the more than 600 leachate analyses conducted, only two showed concentrations in excess of 10 times the National Interim Primary Drinking Water Regulations for selenium (13 and 20 times the standard).

2. Typically, after approximately 2 years, the concentrations of the total dissolved solids (TDS) in the leachates of the chemically treated and untreated ponded wastes have approached levels that approximate saturation with gypsum (approximately 2500 mg/l).

3. The ground waters associated with all sites show no effects attributable to the waste disposal operations.

4. Runoff from waste that was force-oxidized to gypsum shows a TDS concentration of between 2500 and 3200 mg/l, and total suspended solids (TSS) in the same runoff range between 4 and 300 mg/l. When stacked above grade, uncompacted gypsum filter cake exhibits cracking under exposure to freeze-thaw or wet-dry conditions, thereby allowing rainwater to enter into the material. For structural strength of the gypsum filter cake to be maintained, the site should be managed to reconfigure the disposal pile after weathering to shed water so that it is not allowed to reslurry by wetting.

5. The underdraining of untreated waste results in a structually sound material in an impoundment with all seepage and rainfall being controlled. Operationally the water would be returned to the scrubber and reused.

6. Site closure by draining, covering, and contouring with indigenous clay of one chemically treated and two untreated underdrained sites has been shown to be adequate to support construction vehicles.

7. Ponding of untreated material is generally the least costly method of FGD waste disposal, but if the pond does not have a base material considered to be impermeable a liner must be added to reduce seepage, thereby significantly increasing the disposal cost. Since FGD wastes are thixotropic in nature, ponds of untreated wastes are considered nonstructural sites and are generally difficult to reclaim, except possibly in areas of low rainfall and high evaporation.

8. Chemical treatment, ponding with underdrainage, gypsum with an indigenous liner and surface drainage, and chemical treatment with landfilling cost between 0.79 and 1.46 mills/kWh ($7.10 to $14.15/tonne waste, dry basis).

SECTION 3

RECOMMENDATIONS

It is recommended that the following FGD waste disposal, site closure, and reclamation techniques be further evaluated:

1. Long-term monitoring of covered disposal sites to evaluate the effectiveness of site closure, reclamation, and repair. The two sites which were covered with soil and sloped to facilitate runoff of rainwater (one underdrained and one chemically treated) have experienced seepage. This may be due to the recontouring and puncturing of the soil cap for the planting of trees and appears amenable to repair. Another underdrained site, which was covered in April of 1980, has not been effectively evaluated because of the low rainfall since construction.

2. Investigation of the disposal of slurried force-oxidized waste. It has been noted that stacking of gypsum filter cake is subject to slumping and erosion. Although hard surface layers (crusts) form during dry periods, these are not permanent and revert to the original condition during wet periods. Above-ground disposal and costs of slurried FGD gypsum similar to the phosphate gypsum disposal in central Florida have not been assessed.

3. Long-term evaluation of the effects of time and weather on the physical and structural characteristiss of the chemically treated materials. Recent tests of treated waste core samples have shown that although permeabilities are within the range of previous results, values are typically on the lower side. Weathering of a chemically treated site that was converted to a runoff configuration has resulted in the formation of approximately 4 in. of granular waste on the surface. In addition, the top 4 to 6 in. of waste in Site B, which is generally underwater, has deteriorated into a soft silty material with minimum physical strength.

SECTION 4

SUMMARY

The data obtained in the Shawnee FGD waste disposal evaluation are summarized and discussed in this report. The physical characteristics of the wastes were obtained by analysis of the materials prior to disposal and of core samples after disposal. Water samples from each site were analyzed (i.e., leachate or underdrain, runoff, supernate, and ground water) for the evaluation of the chemical characteristics.

4.1 SITE DESCRIPTION

A description of the disposal sites is summarized in Table 1. A view of the disposal site is shown in Figure 2. Seven ponds or surface sites contained untreated waste, and three were filled with chemically treated material. The untreated sites include A1, D, F, G, H, J, and K. Sites A1 and D were considered control sites with lime and limestone (absorbent) waste disposed in ponds containing indigenous soil. Sites F and G were underdrained ponds containing limestone and lime scrubbing wastes. Sites H, J, and K contained wastes that were force-oxidized to gypsum; Site H had a lower ponded portion of underdrained clarifier underflow slurry and an above-ground stack of gypsum filter cake; and Sites J and K had gypsum filter cake stacked on the surface. A total of 14 ground water wells were situated in and around the disposal area and were sampled periodically to monitor any potential effects of the disposal sites on the ground water quality.

Sites B, C, and E were filled with chemically treated material. Site B was filled in April 1975, with clarifier underflow (limestone absorbent), treated by the Dravo Corporation. Site C (Figure 3) also filled in April 1975, contained centrifuge cake (lime absorbent), treated by IU Conversion Systems, Inc. Site E was filled in December 1974 with clarifier underflow (limestone absorbent), treated by Chemfix, Inc. The filling operations and details of the treatment processes are described in Reference 1.

Several of the sites were modified since initial placement (Table 1) to evaluate site retirement and reclamation methods. Chemically treated Site E and underdrained Sites F and G were covered with clay, which was then contoured and planted with grass. Site C was converted to a runoff configuration in March 1979. As a separate EPA/TVA project, the crown of the clay covering of Sites E and F were removed, and several species of small trees were planted in the spring of 1979.

TABLE 1. SHAWNEE DISPOSAL SITES

Site	Fill Date	Scrubber Type[a]	Waste		Solids Content, wt %[c]	Treatment	Remarks
			Absorbent	Source[b]			
A	10/8/74	VST	Lime	F	46	Untreated	Out of service 4/15/76
A1	5/10/76	VST	Lime	F	46	Untreated	Control pond, transferred from Site A
B	4/15/75	TCA	Limestone	CU	38[d]	Dravo	Underwater disposal
C	4/23/75	VST	Lime	CE	55[d]	IUCS	Site converted to runoff mode 3/79
D	2/5/75	TCA	Limestone	CU	38	Untreated	Control pond
E	12/7/74	TCA	Limestone	CU	38[d]	Chemfix	Covered 11/77
F	2/3/77	TCA	Limestone	CU	47	Untreated	Underdrained site, covered 11/77
G	10/5/76	VST	Lime	CE	47	Untreated	Underdrained site, covered 4/80
H	9/2/77	VST	Limestone	CU	33	Untreated[e]	
H	9/30/77	VST	Limestone	F	86	Untreated[e]	Surface site: unreacted limestone, 13% by dry weight
J	12/31/78	VST	Limestone	F	81	Untreated[e]	Surface site, adipic acid additive
K	3/29/79	VST	Limestone	F	80	Untreated[e]	Surface site: unreacted limestone, 25% by dry weight

[a] Venturi and spray tower (VST); turbulent contact absorber (TCA).
[b] Filter (F), clarifier underflow (CU), and centrifuge (CE).
[c] Site H is ash-free. All others: fly ash is approximately 40 wt% of solids content. In Site G, half of fly ash was mixed with waste; the remaining portion was placed in six equally spaced layers.
[d] Prior to chemical treatment.
[e] Force-oxidized to gypsum.

Figure 2. Overview of disposal sites with Shawnee Steam Plant in background

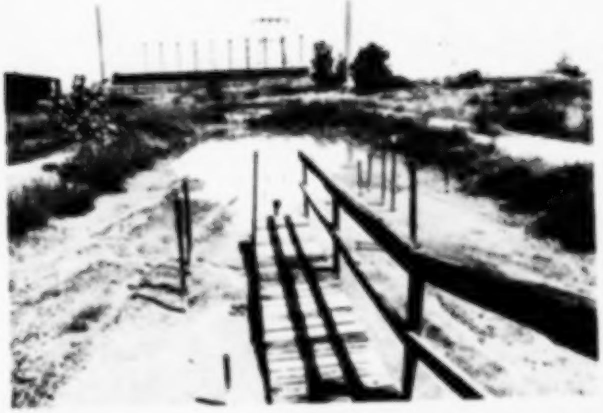


Figure 3. Chemically treated Site C showing original landfill condition

4.2 WASTE CHARACTERISTICS

The disposal sites were filled with FGD waste representing a cross section of scrubber effluent conditions. The discussion of the various methods of waste disposal is divided into the following categories: untreated wastes, chemically treated wastes, gypsum (oxidized calcium sulfite) filter cake, and untreated wastes with underdrainage. Specific properties related to those wastes and methods of treatment are included.

The chemical composition of waste input liquor, water from site runoff, supernate, leachate/underdrainage, and ground water from 14 wells in and around the disposal area were analyzed for a variety of chemical species. The composition of the waste input liquor (before treatment, if any) is summarized in Table 2 and shows a wide range in the concentration of chemical species for the different FGD wastes.

The physical properties considered in the disposal of FGD waste include viscosity, bulk density, moisture content, bearing strength, void fraction, and permeability. Viscosity is important in the transport of the waste to a disposal site; other concerns are the weight and volume of the disposal material, as well as the suitability of the waste as a load-bearing material and deterrent to seepage from a disposal site.

The physical properties of the wastes are dependent upon the characteristics of both the liquid and the solid constituents (Table 3), as well as the interaction between them. These wastes contain finely divided particulate matter in an aqueous medium and consist of three major phases having markedly different morphologies: calcium sulfite hemihydrate ($CaSO_3 \cdot 1/2H_2O$), calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), and fly ash. Both the particle size distribution and phase morphology are believed to influence the physical properties of the wastes. Calcium sulfite and sulfate scrubber waste products tend to have particle sizes in the same range as fly ash, between 1 and 100 μm. However, fly ash is formed as spheres (typically about 10 μm); sulfite waste forms as platelets (limestone) or rosettes (lime); and sulfates are blocky in shape. Unreacted calcium carbonate ($CaCO_3$), from the limestone or precipitated from the lime process, is usually present in the waste and contributes an additional shape parameter.

4.3 UNTREATED WASTE DISPOSAL

A rotary drum mixing truck (ready-mix cement truck) was used to haul the waste to the sites in order to maintain a homogenous mix during loading and transport from the scrubber. Dispersal of the waste in the pond was achieved by dumping at various locations in the pond, from which the waste was allowed to settle and seek its natural level. Two control ponds for untreated lime and limestone scrubbing waste disposal were installed and were monitored principally for the determination of chemical characteristics of the leachate. The material in these ponds, which are identifed in Table 1 as A/A1 and D, was totally saturated (except for extended periods of no rainfall).

TABLE 2. CHEMICAL ANALYSIS OF DISPOSAL SITE INPUT LIQUOR

SITE[a]	pH	CONCENTRATION (mg/l)												
		CALCIUM	SULFATE	CHLORIDE	SULFITE	TOTAL DIS-SOLVED SOLIDS	ARSENIC	BORON	LEAD	MAG-NESIUM	SODIUM	SELE-NIUM	MERCURY	CHEMICAL OXYGEN DEMAND
A	8.3	2,100	1,525	4,600	4	8,560	0.024	44	0.49	280	(b)	0.005	<0.0001	(b)
B	6.9	1,060	1,875	1,850	3	5,160	0.004	97	<0.02	2.5	17	0.020	0.00024	140
C	8.9	2,720	1,575	4,700	45	9,240	0.002	34	<0.01	33	46	0.018	<0.0001	140
D	9.2	1,880	1,500	2,950	56	6,750	0.24	93	<0.02	50	56	0.014	0.0003	140
E	9.4	1,840	1,400	2,700	32	6,190	0.004	80	<0.01	12	41	0.014	0.00033	110
F	12.2	1,990	1,100	2,080	(b)	6,700	0.002	76	<0.01	0.3	70	0.042	<0.0002	43
G	7.8	150	6,600	3,800	(b)	14,000	0.14	83	<0.01	5,000[c]	12	0.63	<0.0002	53
H	7.1	1,300	1,930	3,500	(b)	9,200	<0.003	120	<0.01	540	62	0.14	<0.0002	130
H	(b)	1,510	1,875	6,600	(b)	10,756	(b)	140	(b)	1,100	118	(b)	(b)	(b)
J	5.8	1,250	1,438	3,500	(b)	9,388	0.09	105	0.67	681	107	0.009	0.002	(b)
K	6.9	550	2,250	2,450	(b)	6,694	0.03	95	0.13	764	68	0.035	0.0007	(b)

[a] TABLE 1 LISTS TYPE OF WASTE AT EACH SITE

[b] NOT DETERMINED

[c] MAGNESIA ADDED TO LIME ABSORBENT

TABLE 3. SOLIDS ANALYSIS OF DISPOSAL SITE UNTREATED INPUT WASTES

SITE[a]	SOLIDS CONTENT (% BY WEIGHT)	PERCENT SOLIDS BY DRY WEIGHT			
		CALCIUM SULFITE	CALCIUM SULFATE	CALCIUM CARBONATE	FLY ASH
A	46	(b)	(b)	(b)	(b)
B[c]	38	30.3	10.7	14.2	35
C[c]	55	38.8	9.7	0	40
D	38	29.4	10.9	18.6	33
E[c]	38	27.9	9.4	18.3	34
F	47	33.3	14.8	8.3	40
G	47	(b)	(b)	(b)	20
H	33	0.2	98.0	1.8	0
H	86	0.1	86.8	13.1	0
J	81	0.1	63.7	1.2	35
K	80	0.1	47.1	25.0	28

[a] TABLE 1 LISTS TYPE OF WASTE AT EACH SITE

[b] NOT ANALYZED

[c] SUBSEQUENTLY TREATED CHEMICALLY

The total dissolved solids (TDS) concentration of the initial leachates of the untreated sites A/A1 and D ranged from 6800 to 8600 mg/l. After approximately one year the chloride content of the waste was essentially depleted. Thereafter, the leachate was essentially a saturated gypsum solution, with a TDS concentration of approximately 2500 mg/l. This is illustrated in Figure 4 for Site D leachate. The concentration of the more significant minor species present in these wastes has also been determined (Figure 5). Except for boron, which decreased steadily with time, the minor species have shown only slight reductions after 5 years of seepage. For nearly 900 untreated leachate analyses, four showed the concentration of minor species to be greater than 20 times the National Interim Primary Drinking Water Regulations (12, 14, and 20 times greater for arsenic and 11 times greater for selenium). Under the new Hazardous Waste Management System, all FGD wastes are temporarily exempt from the Federal regulations covering hazardous materials. However, they are subject to state and local regulations; these may include Federal criteria for nonhazardous wastes.

The dewatering characteristics of FGD wastes are important to the various disposal techniques in that they affect the volume of the disposal basin, the waste handling methods, and the condition of the wastes in their final disposal state. The effectiveness of the dewatering methods used and the ability of FGD waste to be dewatered are a function of a number of solids characteristics, including the size and distribution of particles and the crystalline structure of the particles, which are a function of the scrubber system and its operating parameters. In laboratory dewatering tests, four methods were evaluated, using FGD wastes from Shawnee: settling and decanting, settling by free drainage, vacuum filtration, and centrifugation (Table 4).

The highest density was obtained principally by vacuum-assisted filtration. However, the density differences between filtration and centrifugation were relatively small. For most wastes, settling by free drainage yields a slightly greater density than by settling only. Table 4 shows that the wet-bulk densities of limestone scrubbing wastes ranged from a low of approximately 1.45 g/cm^3 for settled wastes to a high of 1.65 g/cm^3 for vacuum filtered. Values for lime scrubbing waste were approximately 7% less than those for limestone scrubbing wastes.

Confined load-bearing strengths of untreated FGD wastes (including gypsum) as a function of solids, absorbent, and fly ash content are presented in Figure 6. Among other considerations, the data highlight the criticality of solids content on the load-bearing strength of untreated wastes. This is of particular importance when considering the disposal of slurried gypsum or untreated FGD wastes that are underdrained, because these types of disposal depend on dewatering to achieve material bearing strength. The test data indicate that these wastes may be dewatered to a narrow range of solids content, above which the load-bearing strengths increase rapidly to values well above the minimum for safe access of personnel and equipment. In addition, the critical concentration appears to be unique for each type of waste tested. Figure 6 also illustrates the effect of the absorbent and fly

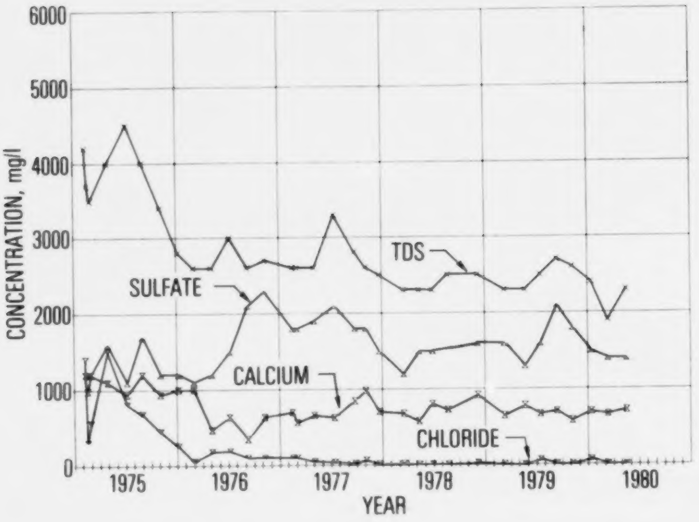


Figure 4. Concentration of TDS and major species in Site D leachate

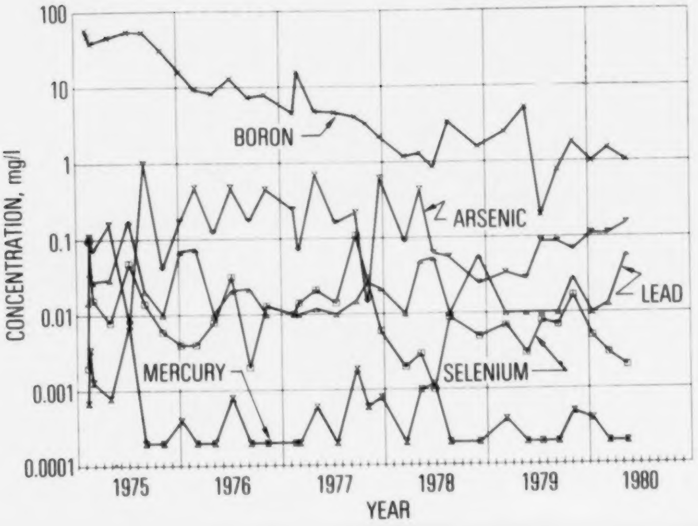
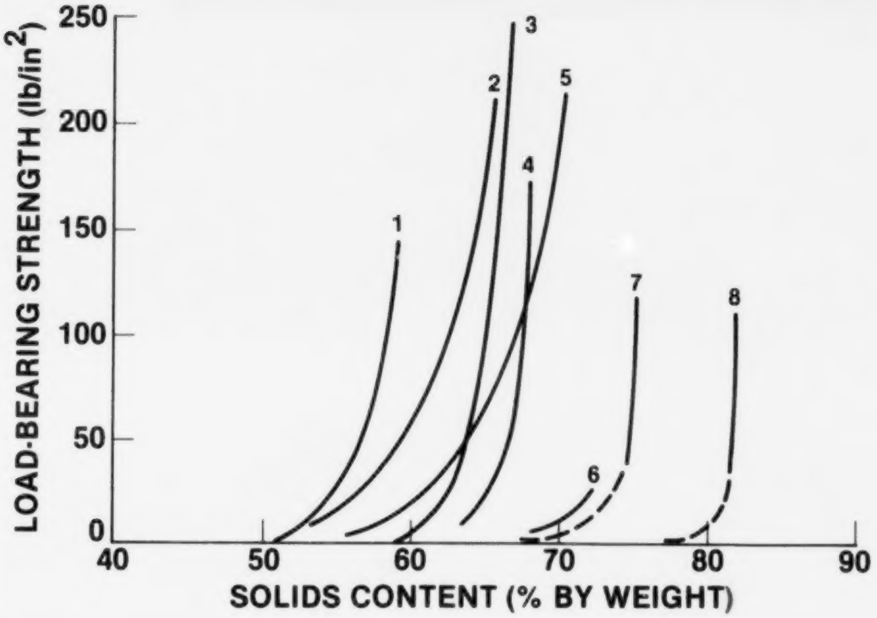


Figure 5. Concentration of minor species in Site D leachate

TABLE 4. BULK DENSITIES OF UNTREATED FGD WASTES

SHAWNEE SOURCE AND SAMPLING DATE	DEWATERING METHOD[a]								
	FLY ASH (% BY DRY WEIGHT)	SETTLING AND DECANTING		SETTLING BY FREE DRAINAGE		CENTRIFUGATION		VACUUM FILTRATION	
		SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)
LIMESTONE									
1 FEB 73	20	49	1.45	56	1.51	60	1.56	65	1.65
15 JUN 74	40	53	1.46	58	1.53	63	1.60	66	1.64
LIME									
19 MAR 74	40	42	1.34	43	1.36	50	1.44	56	1.51
8 SEP 76	40	45	1.34	58	1.50	53	1.44	61	1.54
8 SEP 76	~0	47	1.37	51	1.41	48	1.38	57	1.49

[a] USING LABORATORY EQUIPMENT



CURVE	POWER PLANT	ABSORBENT	FLY ASH (% SOLIDS BY DRY WEIGHT)	SAMPLING DATE
1	SHAWNEE	LIME	<1	8 SEP 76
2	SHAWNEE	LIMESTONE	<1	30 NOV 76
3	SHAWNEE	LIME	40	8 SEP 76
4	RTP[a]	LIMESTONE	<1	4 DEC 75
5	SHAWNEE	LIMESTONE	40	30 NOV 76
6	RTP[a]	LIMESTONE	40	30 SEP 75
7	SHAWNEE[b]	LIMESTONE	<1	SEP 77
8	SHAWNEE[c]	LIMESTONE	<1	2 MAY 79

[a] GYPSUM, CONTAINS 5% SULFITE

[b] GYPSUM SLURRY

[c] GYPSUM CAKE WITH 13% UNREACTED CALCIUM CARBONATE

Figure 6. Confined load-bearing strength of untreated wastes: laboratory data

ash on dewatering and load-bearing characteristics. Limestone scrubbing wastes have critical solids content higher than lime scrubbing wastes. Likewise, the presence of fly ash enhances dewatering in both types of wastes; however, for any specific solids content of a given FGD waste, the load-bearing strength is less when fly ash is present.

The pollution potential of waste liquor seeping into ground waters is governed by the mobility of leaching waters; this mobility is limited by the coefficient of permeability of the various media through which this leachate must pass. The permeability coefficient of untreated wastes (lime and limestone) containing fly ash are approximately 2×10^{-4} cm/sec, which is comparable to typical values for silty sand (10^{-4} cm/sec).

The viscosity of FGD waste is indicative of its pumpability, which could affect both the mode and cost of transport. The results of viscosity tests conducted in the laboratory for various untreated wastes define dewatering limits for certain waste materials if they are to be pumped. The tests also show that pumpable mixtures (considered to be less than 20 poise for slurries) range from a high solids content of 55 wt% to a low of 30 wt% (Figure 7), depending on the absorbent and ash content. For example, the viscosity of the limestone scrubbing at a solids content of 50% is less than lime scrubbing waste at the same solids content. The results also show that FGD wastes of a given type are less viscous if they contain fly ash.

Disposal of untreated material in a pond is usually the least costly method of FGD waste disposal. If the pond does not have a base material considered to be impermeable, a liner must be added to prevent seepage, thereby increasing the disposal costs significantly. Clay or polymeric liners may be placed at the base and on the slopes of such ponds. Any pond continually exposed to weathering, however, may eventually be subject to a degree of seepage because liners are not completely impermeable and, in the case of polymeric membranes, may be subject to varying degrees of physical damage and deterioration. Because FGD wastes are thixotropic in nature, ponds of untreated wastes are nonstructural and are generally difficult to reclaim, except possibly in areas of low rainfall and high evaporation.

4.4 CHEMICALLY TREATED WASTE DISPOSAL

Sites B, C, and E contain wastes that were chemically treated by the Dravo Corporation, IU Conversion Systems, Inc., and Chemfix, Inc., respectively, during late 1974 and early 1975. Site B simulates a disposal condition in which the waste cures underwater and remains underwater, except for periods of extended drought. Site C initially represented a depression in a landfill in which rainwater collects, and Site E represents a landfill that traps rainwater that collects in a sump at its lower end. Site B has remained as originally configured; Site C was converted in March 1979 to a runoff configuration; and in November 1977 Site E was covered with clay, which was then contoured and planted with grass.

CURVE	ABSORBENT	DATE	FLY ASH, WT % (DRY)
1	LIME	9/ 8/76	1
2	LIMESTONE	9/28/76	1
3	LIME	3/19/74	4
4	LIME	9/ 8/76	40
5	LIMESTONE	2/ 1/73	20
6	LIMESTONE	6/15/74	40
7	LIMESTONE	7/11/73	41

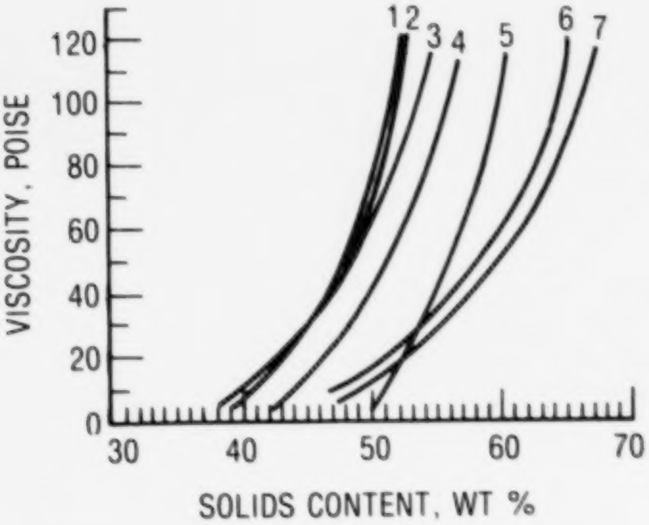


Figure 7. Viscosity of Shawnee FGD wastes

Concentrations of major species in the leachate of chemically treated waste for Sites B and C are presented in Figures 8 and 9, respectively. For Site B leachate, there appeared to be a slow depletion of chloride compared to that of the untreated wastes, while the TDS, sulfate, and calcium concentrations did not change appreciably. In contrast, the Site C leachate showed an initial decrease in TDS. The leachate well for Site C was pumped dry prior to filling. The initial TDS is due to the TDS concentration in the occluded water and is representative of undiluted seepage from the initial placement of waste material. The TDS concentration of all the chemically treated waste leachates generally showed a slight decrease in TDS after the filling period, initially ranging from about 2000 to 5000 mg/l (approximately half the concentration of the untreated liquor) and gradually decreasing in concentration to approximately 2500 mg/l, which is typical of gypsum saturation (Figure 10).

Generally, chemical treatment did not appreciably reduce the concentration of trace elements in the leachate (as shown in Figure 11 for Site C). In some instances, the concentrations of minor constituents in the leachate are somewhat higher than the concentrations in the untreated input liquors. To some extent, this may have resulted from trace elements present in the treatment additives, or from the mobilization of trace elements, such as arsenic and selenium, caused by the pH increase inherent to the treatment process (Ref. 7). Of the more than 600 Shawnee leachate analyses of chemically treated wastes, two showed concentrations greater than 10 times the National Interim Primary Drinking Water Regulations, i.e., 13 and 20 times the regulation for selenium.

Physically, all the chemically treated materials (Table 5) exhibited high bearing capacities. Pond B exhibited ultimate bearing capacities of between 150 and 300 psi, and Sites C and E exceeded 330 psi, which is near the upper limit of the field testing device. However, Site C, which is currently exposed to the weather, developed nearly 4 to 6 in. of granular material on the surface. Similarly, the treated waste in Site B, whose surface is generally underwater, developed a layer of silty material, increasing to a depth of 6 in. at present. These materials exhibit very low bearing capacities.

Laboratory analyses of core samples from these three chemically treated FGD waste sites show widely varying coefficients of permeability as a result of cracks that were present in some core samples (Table 6). In general, the coefficient of permeability for the wastes in Sites C and E are approximately the same and are somewhat less permeable than the Site B material. Although all materials have a permeability of about 10^{-5} cm/sec, which is at least one order of magnitude less than the untreated wastes, several samples from Sites C and E showed coefficients in the range of 10^{-6} to 10^{-7} cm/sec. There does not appear to be a time-dependent trend in the permeability of wastes core samples of the wastes.

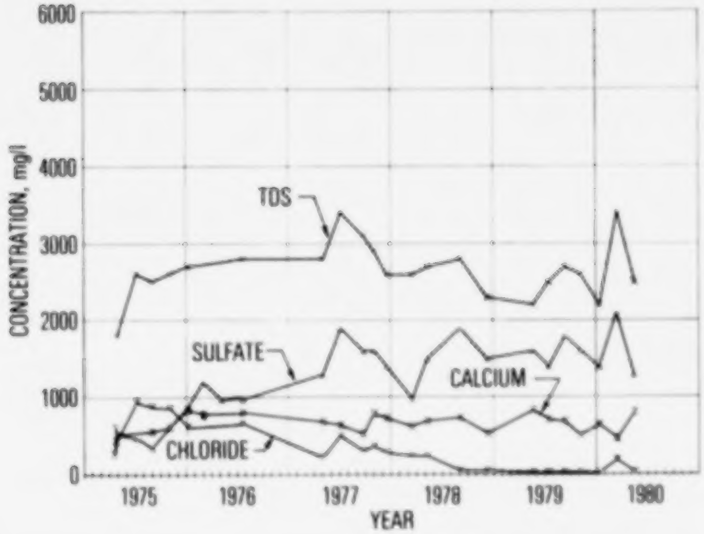


Figure 8. Concentration of TDS and major species Site B in leachate

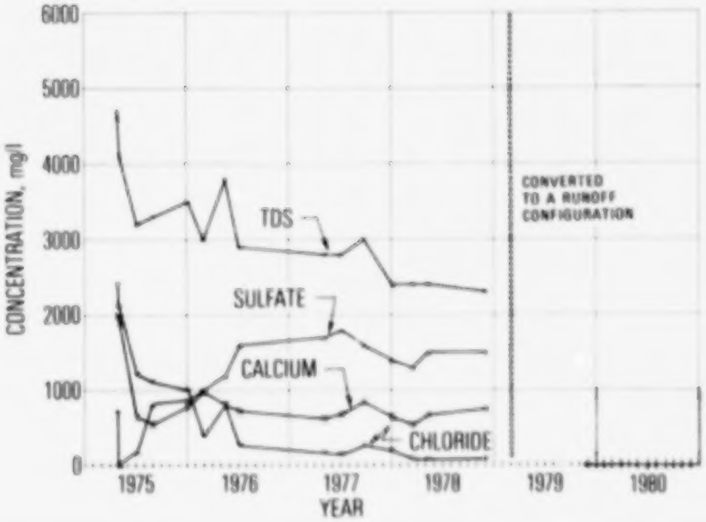


Figure 9. Concentration of TDS and major species Site C in leachate

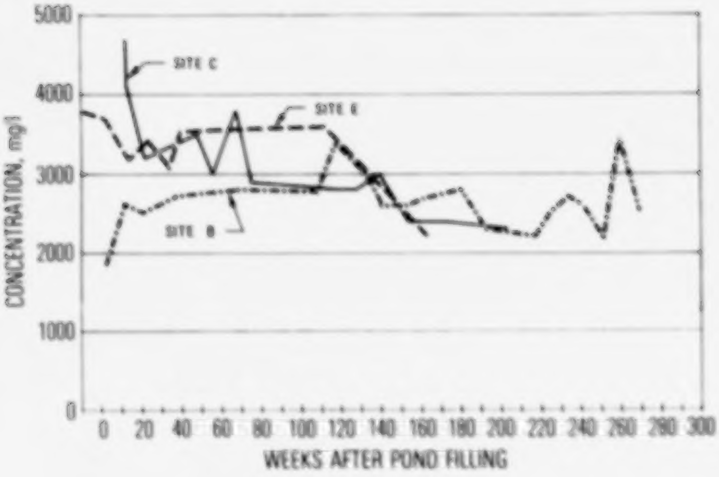


Figure 10. Concentration of TDS in chemically treated waste leachate (Sites B, C, and E)

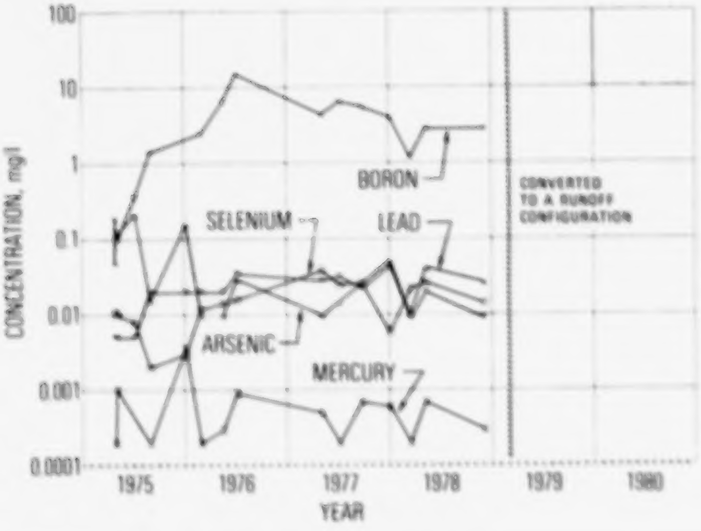


Figure 11. Concentration of minor species in Site C leachate

TABLE 5. ULTIMATE BEARING CAPACITY OF FGD WASTES

Site	Waste Treatment	Ultimate Bearing Capacity	
		kPa	psi
B	Chemical[a]	1035 to 2070	150 to 300
C	Chemical[b]	> 2280	> 330
E	Chemical[c]	2070 to > 2280	300 to > 330
F	None (underdrained)	410 to 520	60 to 75
G	None (underdrained)	1240 to 1650	180 to 240
H	None (underdrained)[d]	930 to > 2280	135 to > 330

[a] Dravo Corporation
[b] IU Conversion Systems, Inc.
[c] Chemfix Corporation
[d] Clarifier underflow
Note: Shawnee clay soil has an ultimate bearing capacity of 1650 to 2070 kPa.

TABLE 6. PHYSICAL CHARACTERISTICS OF IMPOUNDED, CHEMICALLY TREATED FGD WASTE CORE SAMPLES

CHARACTERISTICS	SITE B	SITE C	SITE E
SOLID CONTENT (% BY WEIGHT)	45	61	52
UNCONFINED COMPREHENSIVE STRENGTH, WET kPa (psi)	190 TO 580 (28 TO 84)	280 TO 6900 (40 TO 996)	190 TO 1800 (24 TO 260)
DENSITY (g/cm^3):			
WET	1.37	1.52	1.36
DRY	0.63	0.92	0.70
VOID FRACTION	0.75	0.63	0.71
PERMEABILITY COEFFICIENT (cm/s)	2.1×10^{-4} TO 3.7×10^{-5}	5.2×10^{-5} TO 3.2×10^{-7}	1.1×10^{-4} TO 6.9×10^{-7}

Other physical parameters including solids content, void fraction, and unconfined compressive strength are given in Table 6. Typical solids content for the cores from the three sites were 45% for Site B, 61% for Site C, and 52% for Site E. The average void fractions were 0.75, 0.66, and 0.70 for samples from Sites B, C, and E, respectively. The wide range of values for the unconfined compressive strength of free-standing samples of these materials may be attributed in part to random cracks that were present in some of the test samples.

Stabilization of FGD wastes by chemical treatment offers a solution to the disposal problem in that the potential water pollution can be minimized and the site can be reclaimed. Chemical treatment converts the waste into a structural material, decreases its coefficient of permeability and seepage rate relative to untreated wastes by one to three orders of magnitude, reduces the initial concentration of soluble salt constituents in the leachate by approximately 50%, is amenable to subgrade or above-grade landfilling, and can be contoured to promote the runoff of rainwater.

A general procedure for managing rainfall runoff from a full-scale chemically treated waste disposal site includes collection of the runoff in a peripheral ditch, which directs the water to a settling pond. Depending on the quality of water, e.g., concentration of TDS and total suspended solids (TSS) decanted from this site, it can be discharged to a stream or returned to the scrubber system. After closure of the site, the waste is capped with soil and contoured to support the growth of vegetation and to minimize seepage of rainwater into the waste.

4.5 GYPSUM FILTER CAKE DISPOSAL

Sites J and K and the stacked portion of Site H are limestone scrubbing FGD wastes that were force-oxidized to gypsum and filtered. (The evaluation of the lower portion of Site H, containing clarifier underflow slurried gypsum, is discussed in the following section on underdrained disposal). Input waste characteristics are summarized in Tables 1, 2, and 3. The composition of filter cake samples represented a range of limestone utilization of 97, 80, and 52% corresponding to unreacted limestone concentrations of 1, 13, and 25% for Sites J, H, and K, respectively. Although the filter cake at Site K has a relatively high unreacted limestone content of 25%, it is considered to approximate a portion of the gypsum that will be produced by forced oxidation at the TVA Widows Creek Steam Plant.

These three sites were constructed to determine the impact of piling or stacking FGD gypsum on the ground. Observations were made of the erosion, runoff, water quality, and surface characteristics of the filter cake and crust bearing strength and strength loss when moisture content is increased. Sites H and J were generally conical in shape and approximately 10 ft high, whereas Site K reflected the random dumping of piles of gypsum over an area of 1600 ft^2. Because of the limited size of the piles, compacting of the gypsum during stacking was not performed.

Chemical analyses were made of the leachate collected in the underdrainage system and of runoff samples from Site H. The analysis of the underdrainage is typical of an untreated waste leachate, with concentrations of major and minor chemical species similar to those shown earlier with an initial TDS value of 4000 mg/l, which is continuing to decline toward a saturated gypsum concentration. The concentration of major species in the runoff of Site H shows a slight decrease in TDS over time. The runoff had TDS slightly in excess of 2000 mg/l and TSS ranging between 4 and 300 mg/l, which indicates the need to control runoff in this type of disposal to prevent seepage into underground drinking water supplies or direct discharge into streams. The minor species (Figure 12) show a general decrease in boron, lead, and mercury. However, recent data indicate an increase in arsenic and selenium in the runoff samples. The most recent runoff samples yielded values of arsenic approximately 10 times the National Interim Primary Drinking Water Regulation standards and values of selenium nearly equal to those standards.

At Sites H and J, the gypsum filter cake was stacked so that a natural slope occurred in a conical shape, producing a surface of about 35 degrees to the horizontal. These tests show that erosion would be a potential problem for FGD gypsum filter cake disposed of in this manner. For example, at Site H, after 18 months of weathering, approximately 20% of the mass flowed to the base. At Site J, which was stacked the following year, the same erosion trend developed.

Field penetrometer readings were taken of ultimate bearing capacity on the gypsum stacks. During periods of dry weather, a crust was observed with a thickness varying from approximately 2 in. near the peak to 5 in. at midheight, and 11 in. at the base. Bearing capacities of the crust varied from 60 psi near the peak to 450 psi near the base. Several tests were made with a D-8 Caterpillar tractor at Site J to determine the maximum angle at which the vehicle could negotiate the slope of this material. During testing, the cleats of the tractor broke through the crust, and the vehicle lost traction at an angle of 17 degrees to the horizontal. After approximately six passes over the same spot, the material became so moist that it could not support personnel.

The crust also absorbed water and, during periods of continued rainfall, reverted to a material characteristic of the original FGD gypsum filter cake. When water collected, the gypsum increased in moisture content and approached a slurried condition.

Two sets of FGD gypsum samples that were produced at the pilot FGD scrubber at the EPA Industrial Environmental Research Laboratory at Research Triangle Park were obtained. After laboratory filtration, one set of gypsum samples exhibited substantially higher unconfined compressive strength, 60 psi, than the other set, 20 to 25 psi, which contained about 5% sulfite. The unconfined compressive strength of the samples with the 5% calcium sulfite was approximately equal to that of an FGD waste that is predominantly calcium sulfite.

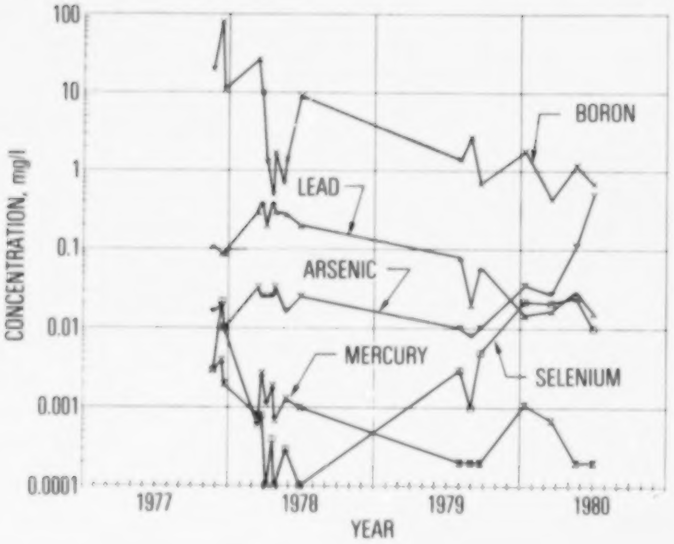


Figure 12. Concentration of minor species in Site H runoff

Typical wet bulk densities for gypsum filter cake with 80% solids content were determined to be in the range of 1.3 to 1.4 g/cm^3. Wet bulk density of Shawnee gypsum clarifier underflow that settled in the impoundment beneath the Site H filter cake pile and was saturated with moisture was approximately 1.7 g/cm^3.

The oxidation of FGD wastes to gypsum results in a waste material that is readily dewatered by vacuum filtration to a solids content in the range of 75 to 85 wt%. When stacked above grade, the filter cake may crack under freeze-thaw or wet-dry conditions, thereby allowing rainwater to enter into the material. Additionally, it may erode when exposed to rainfall and produce a runoff containing concentrations of dissolved solids of approximately 2500 mg/l. These observations indicate that special site maintenance may be required on an operational scale to reconfigure the disposal pile after weathering and to control the runoff. On the basis of experience in phosphogypsum waste management in the fertilizer industry, this is not unexpected.

4.6 UNDERDRAIN DISPOSAL OF UNTREATED WASTES

Sites F and G and the lower portion of gypsum Site H (Figure 13) were evaluated for disposal of untreated FGD waste deposited in an underdrained impoundment. The underdrainage system consisted of a 1-ft thick sand layer at the base of each impoundment, under which perforated plastic pipes, imbedded in pea gravel, collected and fed leachate that seeped through the waste to a sump, through a gravity drain system. Water was pumped from the sump to remove all seepage.

In a properly designed operational site, the underdrainage (and all rainfall on the disposal site) could be recycled to the scrubber. This would effectively reduce the normal amount of fresh makeup water. However, it would increase the concentration of soluble salts, e.g., chloride, in the scrubber loop. The resultant chloride concentration could be as high as 9000 mg/l for lime/limestone scrubber waste and 25,000 mg/l for gypsum waste. These concentrations are not anticipated to be detrimental to scrubber operation; however, steps to prevent scrubber corrosion would be necessary.

The underdrainage enhances dewatering of the material such that the additional settling that results from the removal of the occluded water results in an untreated material with very high bearing capacities when contained in an impoundment (Table 5); these ponds drain rapidly because of their highly porous base. In the Shawnee testing, the underdrained material could support personnel during the pouring operation. Sites G (untreated lime scrubbing waste) and H (gypsum) supported wheeled vehicles within a day after placement (Figure 14). Site F (untreated limestone scrubbing waste), the weakest of the three, did not drain as rapidly as the others but still attained high bearing strength within one week after filling.

Use of an underdrainage system at the disposal site allows for the collection of all seepage for return to the scrubber system, thus, maintaining control of leachate during the fill period. Reclamation of this type of

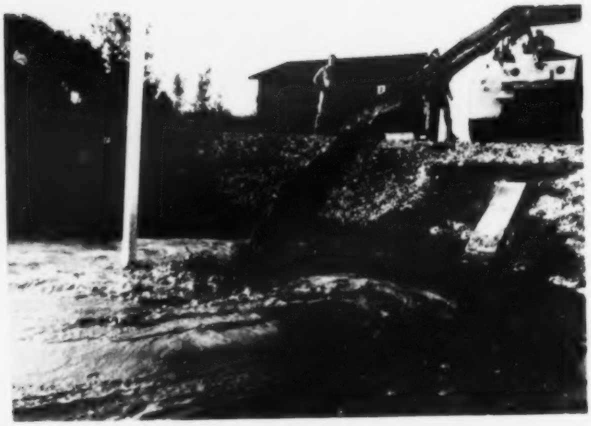


Figure 13. Filling lower portion of Site H with scrubber clarifier underflow that has been force-oxidized to gypsum

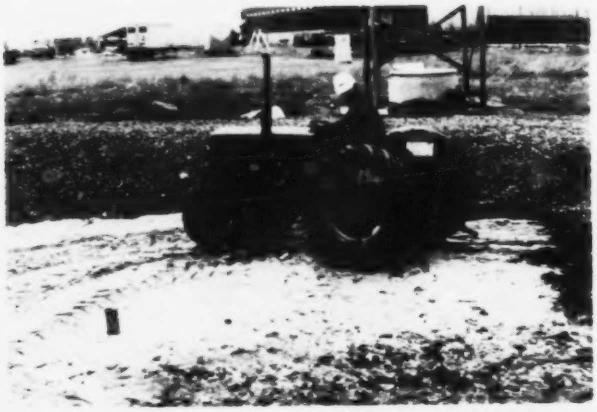


Figure 14. Untreated underdrained Site G showing physical stability within three days after filling

disposal method would require an earthen cap that is contoured and maintained to shed water after disposal site closure. After Site F had been in service for 9 months, all water was removed from the underdrain sump, and the site was covered with a layer of indigenous soil, using a rubber-tired earth mover. This cap, which was contoured and planted with grass so that its surface would shed rainwater, was approximately 3 ft thick at the center line and 2 ft thick at the edges. In the spring of 1979, the soil cap was recontoured and reduced to a constant thickness of 2 ft for a separate EPA/TVA project that included an experimental planting of young trees. Recently, Site F (and chemically treated Site E) has shown increased seepage. This may be due, however, to the recontouring of the soil covering and puncturing of the soil cap for the trees. Underdrained Site G was covered in April of 1980, but because of low rainfall since construction the evaluation of this type of reclamation is inconclusive.

Regarding seepage into the subsoil from an underdrain system, a low hydrostatic pressure exists at the site and subsoil interface because the hydraulic head is interrupted at the porous base and the system is vented to the atmosphere. If, for example, the subsoil coefficient of permeability were 10^{-6} cm/sec, the penetration with underdrainage would be 14 in./yr only in the vicinity of the trenches holding the drainage pipes, which may be approximately 10 in. × 10 in. and as much as 100 ft apart. Penetration of the water into the soil between the drainage trenches would be negligible because the water would be only a film on the base of the site. By comparison, the subsoil seepage from a similar pond without underdrains would be about 6 ft/yr from the entire pond bottom. Considering the depth of seepage and the pond base area contributing to the seepage, the underdrained site would release about 0.4% as much water as the nondrained pond.

4.7 COST ESTIMATES OF FGD WASTE DISPOSAL

Costs were estimated for the various FGD waste disposal methods related to the type of disposal evaluation conducted at Shawnee. The engineering cost estimates for the disposal methods summarized in Table 7 are based on mid-1980 dollars and on other conditions summarized in Table 8. Cost-effective and environmentally sound disposal methods--namely, chemical treatment, untreated with underdrainage, and gypsum with a low permeability indigenous clay liner and surface drainage--cost between 0.79 and 1.46 mills/kWh. The disposal cost of chemically treated waste of 1.46 mills/kWh is based on costs derived from data provided by the three treatment contractors who participated in the Shawnee project and has been updated to mid-1980 dollars.

These cost estimates differ slightly from those presented in previous reports on this project as a result of a revision upward in average unit capacity factors for the power stations and a reduction in disposal land costs. Based on a sampling of U.S. power companies and government agencies, the estimated cost of land was changed from $5000 to $2000/acre. Also, on the basis of recent data, the 30-year average unit capacity factor for new coal-fired utility power plants is now projected at 65% rather than 48.5%. Both of

TABLE 7. COST COMPARISON OF DISPOSAL ALTERNATIVES (MID-1980 DOLLARS)[a]

Disposal	Annual Disposal Costs[c]			Capital Investment Cost	
	Mills/kWh	$/Tonne of Dry Waste	$/Tonne of Coal	$/kW	Significant Cost Items[b]
Untreated Waste Pond Indigenous Liner	0.51	5.01	1.51	14.80	Land (780 acres)
Synthetic Liner (Polymeric)	1.23	11.96	3.62	38.70	Land and liner
Betonite Clay Liner	2.06	20.01	6.04	66.20	Land, clay liner, and clay transportation
Volclay SS-100 Liner	0.94	9.13	2.76	29.00	Land and liner
Underdrained	0.86	8.33	2.51	26.00	Land and underdrainage system
Force-Oxidized Waste with Surface Drainage					
Indigenous Liner	0.79	7.10	2.19	21.20	Oxidation equipment
Synthetic Liner (Polymeric)	1.28	12.22	3.78	39.20	Oxidation equipment and synthetic liner
Chemically Treated Waste Landfill	1.46	14.16	4.78	17.78	Dewatering equipment and chemical reagents

[a] Cost comparisons are for conditions summarized in Table 8.
[b] Relative to the various alternatives presented.
[c] Includes disposal of ash in the waste.

TABLE 8. SUMMARY OF BASE CONDITIONS FOR COST ESTIMATION

Item	Base Condition
Dollar Base	Mid-1980
Electric Utility Plant Size	Two 500-MW units
Coal Burned	3.5% sulfur: 2.8×10^7 J/kg (12,000 Btu/lb) 14% fly ash
Heat Rate	9.5×10^6 J/kWh (9000 Btu/kWh)
Annual Operating Hours	5694 hr (30-yr average for a 65% lifetime capacity factor)
Disposal Site Lifetime	30 yr
SO_2 Removal	90%
FGD Waste Generated	5.8×10^5 tonnes (6.4×10^5 tons)/yr, dry (general case) 6.0×10^5 tonnes (6.6×10^5 tons)/yr, dry (gypsum case)
Limestone Utilization	80% for limestone scrubbing; 100% for forced oxidation to gypsum
Annual Capital Charges, 30-yr Average	17%
Cost of Land Used for Disposal	\$4940/ha (\$2000/acre)
Disposal Site Location	Within one mile of steam plant
Total Disposal Area Requirements, (Including Berm) for a 9-m (30-ft) Waste Depth	
Chemically Treated Waste	263 ha (650 acres)
Force-Oxidized Waste	236 ha (582 acres)
Untreated Waste	
Lined	295 ha (730 acres)
Underdrained	316 ha (780 acres)

these factors caused reductions of about 0.17 mills/kWh for untreated disposal and about 0.44 mills/kWh for the gypsum disposal cases and are reflected in Table 7.

The cost of chemically treated waste disposal increased by 0.21 to 1.46 mills/kWh (Table 7). Although costs declined as a result of the land and capacity factor revisions indicated here, the decrease was offset by the inclusion of capital investment contingency, startup and modification costs, and interest during construction (Table 9), which had been previously applied only to the untreated and gypsum disposal costs.

For the indigenous clay liner case, a soil permeability coefficient of 10^{-7} cm/sec was taken to be representative of clay to be used for pond lining, and consequently no cost was associated with liner material. The cost of pond construction for disposing of untreated and force-oxidized wastes increases to 1.28 mills/kWh if a synthetic liner must be added compared to a cost of 0.79 mills/kWh without a liner. The estimated installed cost of a synthetic liner is $5.40/yd^2.

For the underdrained site, a design for a minimal sand bed using a 1-ft thick sand layer and pipe spacing of 133 ft is the lowest cost design for this type of disposal. Ten 50-acre sites are required for this disposal mode according to the baseline conditions, and the cost is 0.86 mills/kWh. The cost of the underdrainage components, including sand, gravel, pipes, and fittings, is approximately 20% of the total capital cost.

Disposal of force-oxidized FGD waste includes a 15% slurry pumped to the site, where it settles, on the basis of test site data, to approximately 65% solids and the supernate water is recycled to the scrubber. The cost of the oxidation equipment is included as part of the disposal costs.

Differences in capital investment costs for the various alternatives shown in Table 7 are attributable to differing requirements for each type of disposal, e.g., land requirements, whether a synthetic liner or underdrainage system is installed, and the necessity for dewatering, oxidation, or special slurry handling equipment. The least capital intensive method at $14.80/kW is for the untreated case and involves waste disposal in ponds with an indigenous clay base. The most capital intensive technique is for forced oxidation of the waste prior to gypsum and disposal in a pond lined with polymeric material; the cost associated with this option is $39.20/kW. As shown in Table 7, the use of a liner has a marked effect on the cost of disposal. The use of a treated betonite clay liner (Volclay SS-100), a polymeric liner, and a pure betonite clay liner increased the untreated waste disposal cost from $14.80/kW to $29.00, $38.70, and $66.20/kW, respectively.

TABLE 9. CONTINGENCY AND MISCELLANEOUS CAPITAL INVESTMENT COSTS

Item	Cost
Engineering	10% of capital equipment
Miscellaneous Services	0.5% of capital equipment
Contingency	12% of capital equipment, plus engineering, and miscellaneous services
Startup and Modification Allowance	6.7% of capital equipment, plus all of the above
Interest During Construction[a]	1.6% of capital equipment, plus all of the above

[a] Estimated as 4 months.

SECTION 5

TECHNICAL DISCUSSION

The evaluation of the data obtained in the Shawnee flue gas desulfurization (FGD) waste disposal project is described in the following paragraphs. The physical characteristics of the waste were obtained by analysis of material prior to disposal and after disposal (obtained by coring). The core samples were obtained by either a 1-1/2 in.-diam split-spoon sampler for on-site analysis or a Shelby-tube core, which was analyzed at the Aerospace laboratories. Analyses were conducted on water samples from each pond or site (i.e., leachate or underdrain, runoff, supernate, and ground water) for the evaluation of the chemical characteristics. A complete list of all the water analyses, including the data presented here, is given in Appendix D. The procedures used in performing the chemical characterization and physical properties analyses are described in detail in Appendix E.

A description of the disposal sites being evaluated at Shawnee is summarized in Table 10. Seven sites contain untreated waste, and three have been filled with chemically treated material. The untreated sites are as follows: Site Al, lime absorbent, open ponding; Site D, limestone absorbent, open ponding; Site F, limestone absorbent, with underdrain; Site G, lime absorbent, with underdrainage; Site H, limestone absorbent, force-oxidized to gypsum with a lower portion of underdrained slurry and an upper portion of stacked gypsum; and surface Sites J and K, limestone absorbent, force-oxidized to gypsum. All the sites contain approximately 40% ash except for Site H, which is ash-free. In Site G, half of the fly ash was mixed with the waste; the remaining portion was placed in six equally spaced layers.

Sites Al and D are considered control ponds since the open ponding of untreated waste in soil indigenous to the disposal site usually represents the least expensive disposal option. Site A, which was originally located west of the steam plant, was discontinued in April 1976 when the area was needed for the expansion of the coal pile. The waste from Site A was transferred to a new area (Site Al), adjacent to the other sites, in May 1976. A new ground water well was constructed at Site Al in the spring of 1977 and has been monitored since that time.

The three disposal sites being evaluated at Shawnee that have been filled with chemically treated material are Sites B, C, and E. Site B was filled in April 1975 with clarifier underflow (limestone absorbent), treated by the Dravo Corporation. Site C was also filled in April 1975, with centrifuge cake (lime absorbent), treated by IU Conversion Systems, Inc. Site E was filled in December 1974, with clarifier underflow (limestone absorbent),

TABLE 10. SHAWNEE DISPOSAL SITES

Site	Fill Date	Scrubber Type[a]	Waste		Solids Content, wt %[c]	Treatment	Remarks
			Absorbent	Source[b]			
A	10/8/74	VST	Lime	F	46	Untreated	Out of service 4/15/76
A1	5/10/76	VST	Lime	F	46	Untreated	Control pond, transferred from Site A
B	4/15/75	TCA	Limestone	CU	38[d]	Dravo	Underwater disposal
C	4/23/75	VST	Lime	CE	55[d]	IUCS	Site converted to runoff mode 3/79
D	2/5/75	TCA	Limestone	CU	38	Uncreated	Control pond
E	12/7/74	TCA	Limestone	CU	38[d]	Chemfix	Covered 11/77
F	2/3/77	TCA	Limestone	CU	47	Untreated	Underdrained site, covered 11/77
G	10/5/76	VST	Lime	CE	47	Untreated	Underdrained site, covered 4/80
H	9/2/77	VST	Limestone	CU	33	Untreated[e]	
H	9/30/77	VST	Limestone	F	86	Untreated[e]	Surface site: unreacted limestone, 13% by dry weight
J	12/31/78	VST	Limestone	F	81	Untreated[e]	Surface site, adipic acid additive
K	3/29/79	VST	Limestone	F	80	Untreated[e]	Surface site: unreacted limestone, 25% by dry weight

[a] Venturi and spray tower (VST); turbulent contact absorber (TCA).
[b] Filter (F), clarifier underflow (CU), and centrifuge (CE).
[c] Site H is ash-free. All others: fly ash is approximately 40 wt% of solids content. In Site G, half of fly ash was mixed with waste; the remaining portion was placed in six equally spaced layers.
[d] Prior to chemical treatment.
[e] Force-oxidized to gypsum.

treated by Chemfix, Inc. The filling operations and details of the treatment processes are described in Reference 1.

As noted in Table 10, several of the disposal sites have been modified since initial placement. These modifications were undertaken to increase the information obtained from the disposal evaluation by initiating site closure and retirement procedures. Chemically treated Site E and underdrained Sites F and G were covered with clay, which was then contoured and planted with grass. As a separate EPA/TVA project, the crown of the clay covering for Sites E and F were removed, and several species of small trees were planted in the spring of 1979. In addition, Site C was converted to a runoff configuration in March 1979.

5.1 PHYSICAL CHARACTERISTICS

The physical properties considered in the disposal of FGD wastes include density and water retention characteristics, permeability and void fraction, load-bearing and unconfined compressive strength, viscosity, and crystal morphology. The viscosity is particularly important in the transport of the waste to a disposal site; the other properties concern the weight and volume of the disposal material, as well as the suitability of the waste as a load-bearing material and as a means of preventing seepage from a disposal site.

5.1.1 Density and Water Retention Characteristics

The water retention or, conversely, the dewatering characteristics of FGD wastes are important to the various disposal techniques in that they affect the volume of the disposal basin, the waste handling methods, and the condition of the wastes in their final disposal state. Wet-bulk density is a consequence of the dewatering characterisitcs of each waste.

The effectiveness of the dewatering method used and the ability of a waste to be dewatered depend on a number of solids characteristics, including the size and distribution of particles and the crystalline structure of the particles, which are a function of the scrubber system as well as its operating parameters. In a laboratory evaluation, four dewatering methods were considered: settling with decanting, settling by free drainage, vacuum filtration, and centrifugation. The results of these experiments are shown in Table 11.

The highest density was obtained principally by vacuum-assisted filtration. However, there were relatively small density differences between filtration and centrifugation. For most wastes, settling by free drainage yields a slightly greater density than settling only. This slight gain coupled with the associated higher solids content, however, may in some cases significantly increase load-bearing strength (Section 5.1.3). Sites F and G were installed to evaluate the improved physical characteristics resulting from the underdrainage of the disposal site.

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TABLE 11. BULK DENSITIES OF UNTREATED FGD WASTES

SHAWNEE SOURCE AND SAMPLING DATE	DEWATERING METHOD[a]								
	FLY ASH (% BY DRY WEIGHT)	SETTLING AND DECANTING		SETTLING BY FREE DRAINAGE		CENTRIFUGATION		VACUUM FILTRATION	
		SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)	SOLIDS (% BY WEIGHT)	DENSITY (g/cm^3)
LIMESTONE									
1 FEB 73	20	49	1.45	56	1.51	60	1.56	65	1.65
15 JUN 74	40	53	1.46	58	1.53	63	1.60	66	1.64
LIME									
19 MAR 74	40	42	1.34	43	1.36	50	1.44	56	1.51
8 SEP 76	40	45	1.34	58	1.50	53	1.44	61	1.54
8 SEP 76	~0	47	1.37	51	1.41	48	1.38	57	1.49

[a] USING LABORATORY EQUIPMENT

Generally, the wet-bulk density of the untreated limestone wastes ranged from a low of approximately 1.45 g/cm^3 for settled wastes to a high of 1.65 g/cm^3 for vacuum-filtered. Drained and centrifuged values were intermediate to these extremes, with drained being slightly higher than the settled, and centrifuged slightly lower than filtered. Values for lime FGD wastes were approximately 7% less than the limestone waste under laboratory conditions.

Analysis of solid content and wet-bulk density of in-place material was performed, using cores taken periodically from the disposal sites. Table 12 compares recent core analyses to previous core data (a more detailed list is given in Section 5.1.2). The recent analyses indicate no significant change in either the solids contents or wet-bulk densities for any of the untreated or chemically treated wastes. The force-oxidized wastes generally have the highest wet-bulk densities (typically around 1.7 g/cm^3). The wet-bulk density of chemically treated Site C is generally greater than either Site B or Site E, and the range in values for these sites is 1.2 to 1.7 g/cm^3. A comparison of underdrained Sites F and G, with wet-bulk densities of 1.6 and 1.4 g/cm^3, respectively, reinforces the earlier observation that limestone wastes obtain a higher wet-bulk density than do lime wastes. The wet-bulk density of Site D is considerably greater than for a similar limestone scrubbing waste settled under laboratory conditions (i.e., 1.6 versus 1.45 g/cm^3). This is probably due to the continued settling of Site D material during the 5 years after filling. The solids contents of Site D, however, is typical of previous core values.

5.1.2 Permeability

The pollution potential of waste liquor seeping into ground water is governed by the mobility of the leaching waters. This mobility is limited by the coefficient of permeability of the various media through which this leachate must pass. The permeation rate of leaching waters through the waste defines an upper limit to the amount of leachate that enters the subsoil. The amount of liquid and the level of contamination of this liquid are jointly responsible for the pollution potential of any given waste disposal site.

The permeability coefficient of lime or limestone untreated wastes at Shawnee containing fly ash is approximately 2 × 10^{-4} cm/sec in laboratory experiments. Analysis of recent waste cores shows the permeability for untreated underdrained waste to be different for each of the various types of waste materials. Analysis of underdrained Site F cores gave a permeability coefficient of about 3 × 10^{-5} cm/sec, whereas underdrained Site G had a permeability coefficient of approximately 10^{-3} cm/sec. The higher permeability of Site G is probably due, in part, to the layering of fly ash within the waste material. Analysis of a gypsum core from Site J gave a permeability coefficient of 7.9 × 10^{-5} cm/sec. A summary of these untreated waste permeabilities are given in Table 13. As a comparison, typical values for silty sand and sandy clay are 10^{-4} cm/sec and 5 × 10^{-6} cm/sec, respectively (Ref. 2).

TABLE 12. COMPARISON OF RECENT WASTE CORE DATA TO PREVIOUS PHYSICAL ANALYSIS

	Solids Content, wt %				Wet-Bulk Density, g/cm^3	
Type	Site	Input	Previous Cores[a]	April 1980 Core Sample	Previous Cores[a]	April 1980 Core Sample
Untreated	D	38	55	57	--	1.6
Untreated/ Underdrain	F	47	60	58	1.6	1.6
	G	47	57	64	1.4	1.4
	B	38[b]	42-51	43	1.3-1.4	1.3
Treated	C	55[b]	58-64	60	1.4-1.7	1.5
	E	38[b]	49-63	53	1.2-1.4	1.3
	H	33	--	74	--	1.7
	H[c]	86	67	68	1.8	1.8
	J[c]	81	--	78	--	1.7
	K[c]	80	--	80	--	1.8

[a] Average values from Table 15.

[b] Prior to chemical treatment.

[c] Filter cake.

TABLE 13. PERMEABILITY OF SHAWNEE UNTREATED WASTES[a]

Waste Material	Core Sample	Permeability Coefficient, cm/sec
Lime[b]	--	1.8×10^{-4}
Limestone[b]	--	2.0×10^{-4}
Limestone	Underdrained Site F	3.0×10^{-5}
Lime	Underdrained Site G	1.0×10^{-3}
Gypsum	Surface Site J	7.9×10^{-5}

[a] All samples contain fly ash (40% by dry weight).
[b] Laboratory experiment of settled clarifier underflow.

Laboratory consolidation of lime and limestone untreated wastes, under pressures of 30 to 100 psi, reduced the void fraction and also reduced the permeability coefficients (Table 14). The higher solid volume fraction, resulting from compaction or consolidation, and the resultant decrease in permeability appear to be a function of the size of the waste particles and the size and distribution of the fly ash particles. Consolidation of untreated waste at the base of a 40-ft deep disposal site may decrease permeabilities by one order of magnitude or greater compared with the permeability at the surface.

Tests were conducted to determine the permeability, moisture content, wet and dry density, and unconfined compressive strength of the core samples obtained from chemically treated Sites B, C, and E. These analyses are summarized in Table 15. Permeability coefficients determined recently ranged from 5.6×10^{-5} cm/sec for Site B, to 9.7×10^{-5} cm/sec for Site C, and 2.5×10^{-4} cm/sec for Site E, although extremes of 2.1×10^{-4} and 3.2×10^{-7} cm/sec were recorded in previous years. The recent values were within the range of results obtained previously for these sites, indicating no apparent time-dependent trends in the permeability coefficient of these chemically treated wastes. It should be noted that the laboratory permeability tests were conducted in selected samples chosen to be as crack-free as possible in order to maintain consistency and continunity in the test results. However, in the field, the waste contained in a multiacre disposal site is subject to the effects of heavy equipment operations, weather, and other factors, which could induce the formation of cracks and voids, thereby increasing the permeability of these materials. As the results indicate, chemical treatment can reduce the permeability coefficient of wastes by factors 500 times that of untreated material. In general, however, a reduction of 10 times appears typical. The actual reduction realized, of course, would be a function of the conditions at a specific site.

5.1.3 Structural Characteristics

The structural characteristics of the FGD waste are important when land reclamation is desired. Analysis of the physical strength of the untreated and chemically treated waste was performed, using three separate tests: (1) unconfined compressive strength, which is taken as the maximum load attained per unit area of an unconfined rectangular sample cut from a waste core; (2) load-bearing strength (modified California Bearing Ratio Test), which is performed on an undisturbed core sample and is taken as the maximum penetration load attained per unit area; and (3) ultimate bearing capacity, which is performed in the field on undisturbed waste material and is taken as the maximum penetration load attained per unit area. The procedures used in these tests are outlined in Appendix E.

Unconfined Compressive Strength

Untreated flue gas cleaning (FGC) wastes are generally not amenable to unconfined compressive strength measurements since an unsupported sample will normally crumble or flow. A comparison of the chemically treated

TABLE 14. EFFECT OF COMPACTION ON PERMEABILITY OF UNTREATED WASTE[a]

Waste	Void Fraction	Permeability Coefficient, cm/sec
Lime	0.75	1.8×10^{-4}
	0.68	6.0×10^{-5}
	0.60	1.4×10^{-5}
	0.54	7.3×10^{-6}
Limestone	0.69	2.0×10^{-4}
	0.56	6.0×10^{-5}

[a] Compaction pressures were 30 to 100 psi.

TABLE 15. PHYSICAL CHARACTERISTICS OF IMPOUNDED TREATED WASTE CORES

Site	Coring Date	Solids Content, wt %	Density, g/cm^3 (wet)	Unconfined Compressive Strength, lb/in^2 (wet)	Density, g/cm^3 (dry)	Void Fraction (volumetric)	Permeability Coefficient, cm/sec
B	5/29/75	51	1.43	62	0.73	0.71	--
B	6/12/75	42	1.40	30	0.61	0.76	6.9×10^{-5}
B	7/30/75	44	1.30	28	0.56	0.77	1.4×10^{-4}
B	1/14/76	46	1.37	84	0.63	0.75	3.8×10^{-5}
B	7/7/76	44	--	35	--	--	2.1×10^{-4}
B	3/15/77	44	1.36	10	0.63	--	--
B	9/28/77	45	1.35	29	0.61	--	3.7×10^{-5}
B	4/15/80	45	1.33	--	0.59	--	5.6×10^{-5}
C	5/29/75	63	1.69	462	1.07	0.58	5.5×10^{-5}
C	6/12/75	59	1.42	321	0.80	0.68	5.5×10^{-7}
C	1/14/76	61	1.50	40	0.91	0.64	3.2×10^{-7}
C	7/7/76	62	1.50	225	0.93	--	5.2×10^{-5}
C	3/15/77	62	1.50	90	0.93	--	5.6×10^{-5}
C	9/27/77	64	1.52	996	0.97	--	2.4×10^{-6}
C	8/14/78	58	1.46	50	0.85	--	9.8×10^{-7}
C	4/15/80	62	1.48	--	0.92	--	9.7×10^{-5}

TABLE 15. PHYSICAL CHARACTERISTICS OF IMPOUNDED TREATED WASTE CORES (Continued)

Site	Coring Date	Solids Content, wt %	Density g/cm^3 (wet)	Unconfined Compressive Strength, lb/in^2 (wet)	Density g/cm^3 (dry)	Void Fraction (volumetric)	Permeability Coefficient, cm/sec
E	2/27/75	49	1.43	118	0.71	0.72	1.5×10^{-5}
E	2/27/75	--	--	--	--	--	2.7×10^{-5}
E	7/29/75	--	--	--	--	--	9.3×10^{-5}
E	1/14/76	52	1.43	24	0.74	0.70	1.2×10^{-5}
E	7/7/76	49	1.33	260	0.63	--	1.5×10^{-5}
E	3/15/77	53	1.30	--	0.69	--	1.6×10^{-6}
E	9/27/77	48	1.34	37	0.65	--	1.1×10^{-4}
E	8/14/78	63	1.28	--	0.81	--	6.9×10^{-7}
E	4/15/80	45	1.31	--	0.65	--	2.5×10^{-4}

--Indicate values not determined.

wastes, however, can be made. Sites C and E had values typically higher than Site B. The results of tests for unconfined compressive strength of samples taken from treated wastes are shown in Table 15: Site B showed values between 10 and 84 psi; Site C, between 90 and 996 psi; and Site E, between 24 and 260 psi.

Load-Bearing Strength

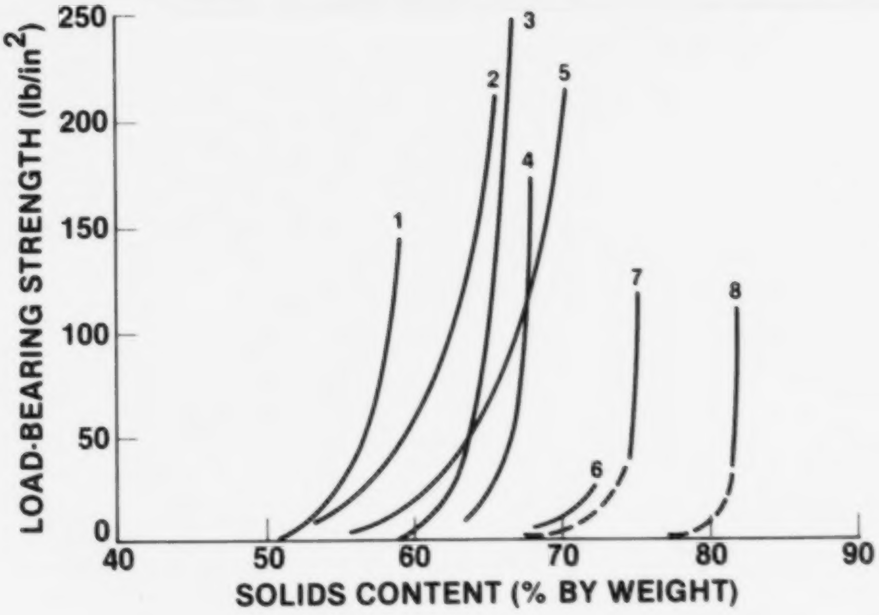
Laboratory analysis of confined load-bearing strengths of untreated wastes, including gypsum, as a function of moisture, fly ash content, and type of SO_2 absorbent are presented in Figure 15. Among other considerations, the data highlight the effect of dewatering and the criticality of solids content on the load-bearing strength. This is of particular importance when considering the disposal of slurried gypsum, gypsum filter cake, or untreated wastes that are underdrained because these types of disposal depend on dewatering to attain a higher material bearing strength. Figure 15 shows that there is a very narrow range of solids content for any given waste over which its strength will decrease rapidly from an extremely high value to virtually zero. When there is an external application of water to a disposal site (e.g., rainfall) there should be operating or maintenance provisions to minimize absorption of the water by the waste or to remove the absorbed water if it should occur. This could be achieved by covering the site and providing runoff collection or by underdrainage of the disposal site.

Figure 15 also illustrates the effect of the absorbent and fly ash on physical characteristics. As contrasted to lime, limestone wastes are capable of being dewatered to a higher solids content (Section 5.1.1); however, lime wastes generally attain high bearing strengths at a lower solids content than limestone wastes. The presence of fly ash enhances dewatering in both types of wastes. For any specific solids content of a given waste, the load-bearing strength is less with fly ash than without.

Analyses of recent core samples for untreated and chemically treated wastes generally show a greater load-bearing strength for the treated wastes. Because of the limited number of core samples, the data, given in Table 16, represent single measurements. Samples from Sites C and E exhibit the greatest overall strength, although Site E shows considerable variation in load-bearing strength. Chemically treated Site B shows values similar to untreated underdrained Site G material or gypsym from Site J.

Ultimate Bearing Capacity

The results of the on-site tests of the ultimate bearing capacity made with a field-type penetrometer, are shown in Table 17. The values indicate that chemically treated waste and untreated waste that has been underdrained or oxidized to gypsum can have relatively high bearing capacity strengths on or near the surface of the material. The chemically treated sites and the gypsum site showed bearing capacities of 300 psi or greater. Underdrained Sites F and G showed maximum values of 75 and 240 psi, respectively.



CURVE	POWER PLANT	ABSORBENT	FLY ASH (% SOLIDS BY DRY WEIGHT)	SAMPLING DATE
1	SHAWNEE	LIME	<1	8 SEP 76
2	SHAWNEE	LIMESTONE	<1	30 NOV 76
3	SHAWNEE	LIME	40	8 SEP 76
4	RTP[a]	LIMESTONE	<1	4 DEC 75
5	SHAWNEE	LIMESTONE	40	30 NOV 76
6	RTP[a]	LIMESTONE	40	30 SEP 75
7	SHAWNEE[b]	LIMESTONE	<1	SEP 77
8	SHAWNEE[c]	LIMESTONE	<1	2 MAY 79

[a] GYPSUM, CONTAINS 5% SULFITE

[b] GYPSUM SLURRY

[c] GYPSUM CAKE WITH 13% UNREACTED CALCIUM CARBONATE

Figure 15. Confined load-bearing strength of wastes as a function of solids and fly ash content

TABLE 16. CONFINED LOAD-BEARING STRENGTH OF RECENT WASTE CORES

Site[a]	Approximate Depth of Sample, ft	Load-Bearing Strength, psi
D	2	110
F	1	130
G	0.5	220
	3	740
J	1	280[b]
	5	820
B	1	340
	2	390
	3	250[b]
C	0.5	1700
	1	5700
	2	4500
	2.5	4100
E	1	150
	2	7900
	3	740
	3.5	1300

[a] Cores were taken in April 1980 and are single measurements, except where noted.

[b] Average of two measurements.

[c] No load - bearing strength at the surface.

TABLE 17. FGD WASTE ULTIMATE BEARING STRENGTH FIELD MEASUREMENTS

Disposal Site and Absorbent	Bearing Capacity, psi[a]		
	Distance Below Waste Surface		
	1-2 in.	2-4 in.	4-6 in.
Pond B,[b,c] Lime	10-15	150	150-300
Site C, Limestone[c]	150-330	240-300	330
Site E, Limestone[c]	75-300	90-300	300-330
Site F, Limestone	50-75	60-75	60-75
Site G, Lime	100-150	100-150	180-240
Site H, Gypsum[d]	330	330	>330
Soil (Shawnee Clay)	60-100	120	240-300

[a] Data taken in August 1977 within 24 hr following a 3.3-in. rainfall; >330 psi represent maximum reading of field penetrometer.

[b] Pond B covered by 4-in. of water.

[c] Chemically treated.

[d] Tests for Site H made on settled and drained clarifier underflow.

The reason for the low values on the top layer of Site B has not been definitely established, but they may have been caused by freeze-thaw effects since the surface of the pond was without supernate during the winter prior to the analysis and weather data recorded during those months show 74 freeze-thaw cycles during a period of 120 days, or 62% of the total days. A contributing factor to the effects of the freeze-thaw cycling of Site B waste is its relatively low solids content, typically around 44%, which is the lowest of the three chemically treated materials.

5.1.4 Viscosity

The viscosity of the waste is indicative of its pumpability, which affects both the mode and cost of waste transport. The results of viscosity tests for various FGD untreated wastes from the Shawnee test facility show that easily pumpable mixtures (estimated at less than 20 poise) range from a high solids content of 55 wt% percent to a low solids content of 40 wt% (Figure 16).

The physical properties of FGD wastes depend on the characteristics and interaction of the liquid and the solid constituents. These wastes contain finely divided particulate matter (e.g., calcium sulfite, calcium sulfate, and fly ash) in an aqueous medium. The laboratory data presented in Figure 16 clearly suggest that fly ash decreases the viscosity of the waste. For example, for a given solid content, limestone and lime scrubbing wastes with fly ash (curves 1 through 5) have a markedly lower viscosity than the waste without fly ash (curves 6 and 7). It was also observed that the presence of fly ash has more of an effect on limestone waste than on lime waste in reducing viscosity.

5.1.5 Crystal Morphology

The physical properties of FGD wastes depend on the characteristics and interaction of the liquid and the solid constituents. These wastes contain finely divided particulate matter in an aqueous medium. Depending on the particulate size distribution and crystal structure, these particles--the majority being calcium sulfite hemihydrate ($CaSO_3 \cdot 1/2H_2O$), calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), and fly ash--influence the physical properties of the wastes. Both calcium sulfite and calcium sulfate scrubber waste products tend to have particles in the same size range as fly ash, i.e., between 1 and 100 μm. Fly ash forms as spheres (typically about 10 μm), whereas sulfite wastes form as platelets (limestone) or rosettes (lime) and sulfates are blocky in shape. Typically all are somewhat larger than fly ash. Unreacted calcium carbonate ($CaCO_3$) from the limestone or precipitated from the lime process usually is present in the waste and contributes an additional shape parameter. Table 18 lists the solids analysis of all waste before treatment, oxidation, or disposal, as appropriate.

In waste materials containing a large percentage of sulfite, i.e., Sites A through F, the presence of the sulfate has not been found to affect the physical properties of the wastes. However, for gypsum waste, in which

CURVE	ABSORBENT	DATE	FLY ASH, WT % (DRY)
1	LIME	9/ 8/76	1
2	LIMESTONE	9/28/76	1
3	LIME	3/19/74	4
4	LIME	9/ 8/76	40
5	LIMESTONE	2/ 1/73	20
6	LIMESTONE	6/15/74	40
7	LIMESTONE	7/11/73	41

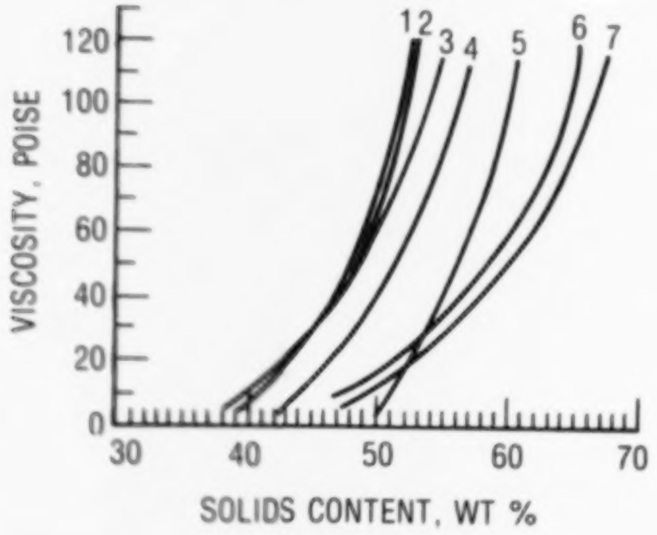


Figure 16. Viscosity of Shawnee FGD wastes

TABLE 18. SOLIDS ANALYSIS OF DISPOSAL SITE UNTREATED INPUT WASTES

SITE[a]	SOLIDS CONTENT (% BY WEIGHT)	PERCENT SOLIDS BY DRY WEIGHT			
		CALCIUM SULFITE	CALCIUM SULFATE	CALCIUM CARBONATE	FLY ASH
A	46	(b)	(b)	(b)	(b)
B[c]	38	30.3	10.7	14.2	35
C[c]	55	38.8	9.7	0	40
D	38	29.4	10.9	18.6	33
E[c]	38	27.9	9.4	18.3	34
F	47	33.3	14.8	8.3	40
G	47	(b)	(b)	(b)	20
H	33	0.2	98.0	1.8	0
H	86	0.1	86.8	13.1	0
J	81	0.1	63.7	1.2	35
K	80	0.1	47.1	25.0	28

[a] TABLE 1 LISTS TYPE OF WASTE AT EACH SITE

[b] NOT ANALYZED

[c] SUBSEQUENTLY TREATED CHEMICALLY

the major component is sulfate, laboratory tests show that small amounts of sulfite have an effect on the physical properties.

Two sets of gypsum samples were obtained from the pilot FGD scrubber at EPA's Industrial Environmental Research Laboratory at Research Triangle Park. After filtration, one set of samples that was completely oxidized exhibited substantially higher unconfined compressive strength (60 psi) than the other set (20 to 25 psi), which contained about 5% sulfite. The unconfined compressive strength of the samples containing about 5 percent calcium sulfite was approximately equal to that of FGD waste that is predominantly calcium sulfite. Also, the presence of fly ash had little effect on the strength exhibited by any of these samples.

5.2 CHEMICAL CHARACTERISTICS

The chemical composition of the FGD waste material was analyzed during the initial placement of each disposal site. Water samples were then taken and analyzed bimonthly to assess the quality of leachate or underdrain water, site runoff or supernate (where applicable), and ground water from 14 wells in and around the disposal area. A variety of chemical species and elements were routinely measured, including total dissolved solids (TDS), sulfate, calcium, chloride, arsenic, boron, lead, mercury, and selenium. A complete listing of these and other analyses is compiled in Appendix D.

The following paragraphs discuss major trends and highlight results from the analysis of the water samples. In addition to the bimonthly sampling, a more complete chemical characterization, which included a variety of trace elements, was performed periodically on the leachate and underdrain water samples.

The composition of all of the waste input liquors, which was analyzed before chemical treatment for Sites B, C, and E, is shown in Table 19. These input liquors show a wide range in concentration of both major (calcium, chloride, sulfate, and TDS) and minor (arsenic, boron, lead, mercury, and selenium) species.

5.2.1 Leachate/Underdrainage

Untreated Wastes

When Site A (lime absorbent) was filled in late 1974, the TDS concentration rose to a level approximately equal to the input liquor TDS concentration. Within 9 months, the TDS began a steady decrease (Figure 17). The major constituents in the leachate, with the exception of sulfate, which has remained relatively constant throughout the monitoring period, have steadily decreased in concentration until 1978. When the waste material was transferred from Site A to Site A1 in 1976, there was no discernible change in the decreasing trend of the TDS level. By mid-1978, the TDS concentration had dropped to a constant level of approximately 2300 mg/l; the chloride was virtually depleted; the calcium concentration had dropped and remained at

TABLE 19. CHEMICAL ANALYSIS OF DISPOSAL SITE INPUT LIQUOR

SITE[a]	pH	CONCENTRATION (mg/l)												
		CALCIUM	SULFATE	CHLORIDE	SULFITE	TOTAL DIS-SOLVED SOLIDS	ARSENIC	BORON	LEAD	MAG-NESIUM	SODIUM	SELE-NIUM	MERCURY	CHEMICAL OXYGEN DEMAND
A	8.3	2,100	1,525	4,600	4	8,560	0.024	44	0.49	290	(b)	0.005	<0.0001	(b)
B	8.9	1,060	1,875	1,850	3	5,160	0.004	97	<0.02	2.5	17	0.020	0.00024	140
C	8.9	2,720	1,575	4,700	45	9,240	0.002	34	<0.01	33	46	0.016	<0.0001	140
D	9.2	1,840	1,500	2,950	56	6,750	0.24	93	<0.02	50	56	0.014	0.0003	140
E	9.4	1,880	1,400	2,700	32	6,190	0.004	80	<0.01	12	41	0.014	0.00033	110
F	12.2	1,990	1,100	2,000	(b)	6,700	0.002	76	<0.01	0.3	70	0.042	<0.0002	43
G	7.8	150	6,600	3,600	(b)	14,000	0.14	93	<0.01	5,000[c]	12	0.63	<0.0002	53
H	7.1	1,300	1,930	3,100	(b)	9,200	<0.003	120	<0.01	540	62	0.14	<0.0002	130
H	(b)	1,510	1,875	6,900	(b)	10,756	(b)	140	(b)	1,100	116	(b)	(b)	(b)
J	5.8	1,250	1,438	3,500	(b)	9,398	0.09	105	0.67	661	107	0.008	0.002	(b)
K	6.9	550	2,250	2,450	(b)	8,694	0.03	95	0.13	764	68	0.035	0.0007	(b)

[a] TABLE 1 LISTS TYPE OF WASTE AT EACH SITE

[b] NOT DETERMINED

[c] MAGNESIA ADDED TO LIME ABSORBENT

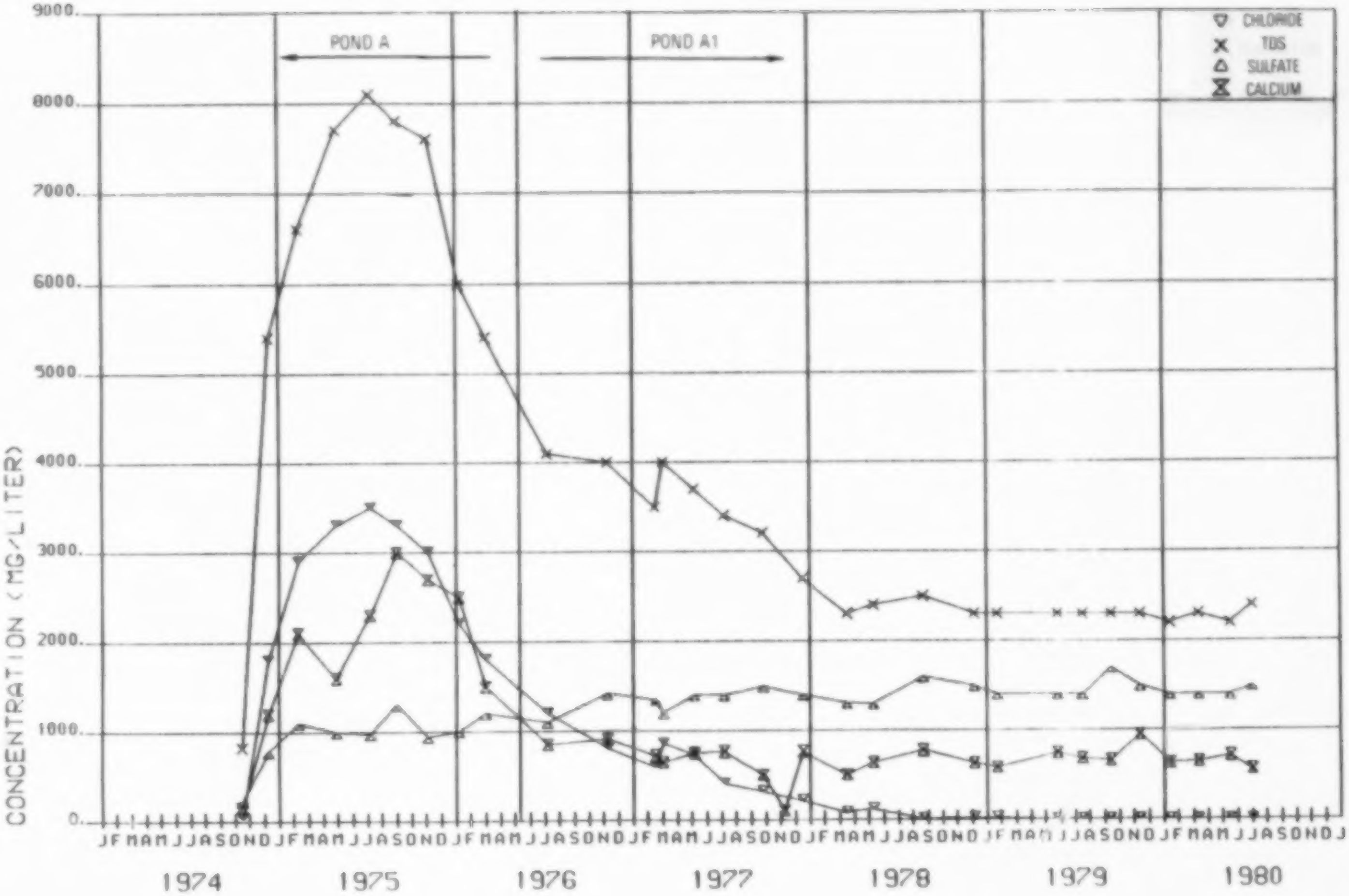


Figure 17. Concentration of TDS and major species in Site A/A1 leachate

approximately 800 mg/l; and the sulfate concentration retained its level of approximately 1400 mg/l. The trends of the minor species in the Pond A/A1 leachate concentrations of arsenic, lead, and selenium have remained relatively constant, with mercury decreasing slightly in the second year of operation and boron continuing a gradual decrease that apparently began in early 1978. The concentrations of the minor species plotted as a function of time are shown in Figure 18.

The leachate in untreated Site D (limestone absorbent) showed a decrease in TDS immediately after pond filling and decreased to 2300 mg/l from a value of nearly 4500 mg/l in mid-1975 (plotted in Figure 19). The chloride in the waste is also virtually depleted, leaving sulfate as the main constituent (1500 mg/l), a calcium at a level less than 1000 mg/l. The six minor species monitored in the Site D leachate have shown a slight decrease in boron concentration, whereas the concentrations of arsenic, selenium, lead, and mercury remained relatively constant except for what appears to be some seasonal variations. A plot of the results of the analyses for minor species in the Site D leachate is shown in Figure 20.

Analyses of the underdrain water from Site F show that the TDS concentration dropped from an input value of 6700 mg/l (Table 19) to approximately 4000 mg/l within 3 months after the pond was filled (see Appendix D for data listing). Thereafter, the TDS concentration remained essentially constant at a level of approximately 4000 mg/l for a period of 6 additional months until the site was covered in November 1977. The underdrain mode shows a rapid drop in dissolved constituents as compared to sites not equipped with underdrain systems. Of the six minor species monitored in the underdrain water, arsenic, boron, lead, mercury, and selenium remained at rather constant concentrations.

The TDS concentration in the input liquor for Site G showed an average of 14,000 mg/l, and analyses of the underdrain water showed that within 6 months after filling the TDS concentration had dropped to levels between 2200 and 4300 mg/l. The TDS concentration has continued to gradually decrease from roughly 3000 to 1800 mg/l (Figure 21). The six minor species monitored in the Site G underdrain showed the typical concentration profiles of the minor species (Figure 22).

The analyses of water from underdrained Site H (gypsum clarifier underflow, filter cake) showed the input slurry liquor to have a TDS concentration of 9200 mg/l, with concentration of nearly 11,000 mg/l TDS from the liquor in the filter cake. The underdrain water showed a decrease in TDS through the first 10 months to a level of 3500 mg/l, followed by a sharp increase to a concentration of 7000 mg/l (Figure 23). This increase in TDS was probably due to liquor from the filter cake reaching the underdrain system. The TDS has gradually declined, although slower than the initial underdrain TDS concentration, to the present level of 3800 mg/l. The results of the analysis of the minor species in the Pond H underdrain water show values of the minor species similar to the leachates discussed above (Figure 24).

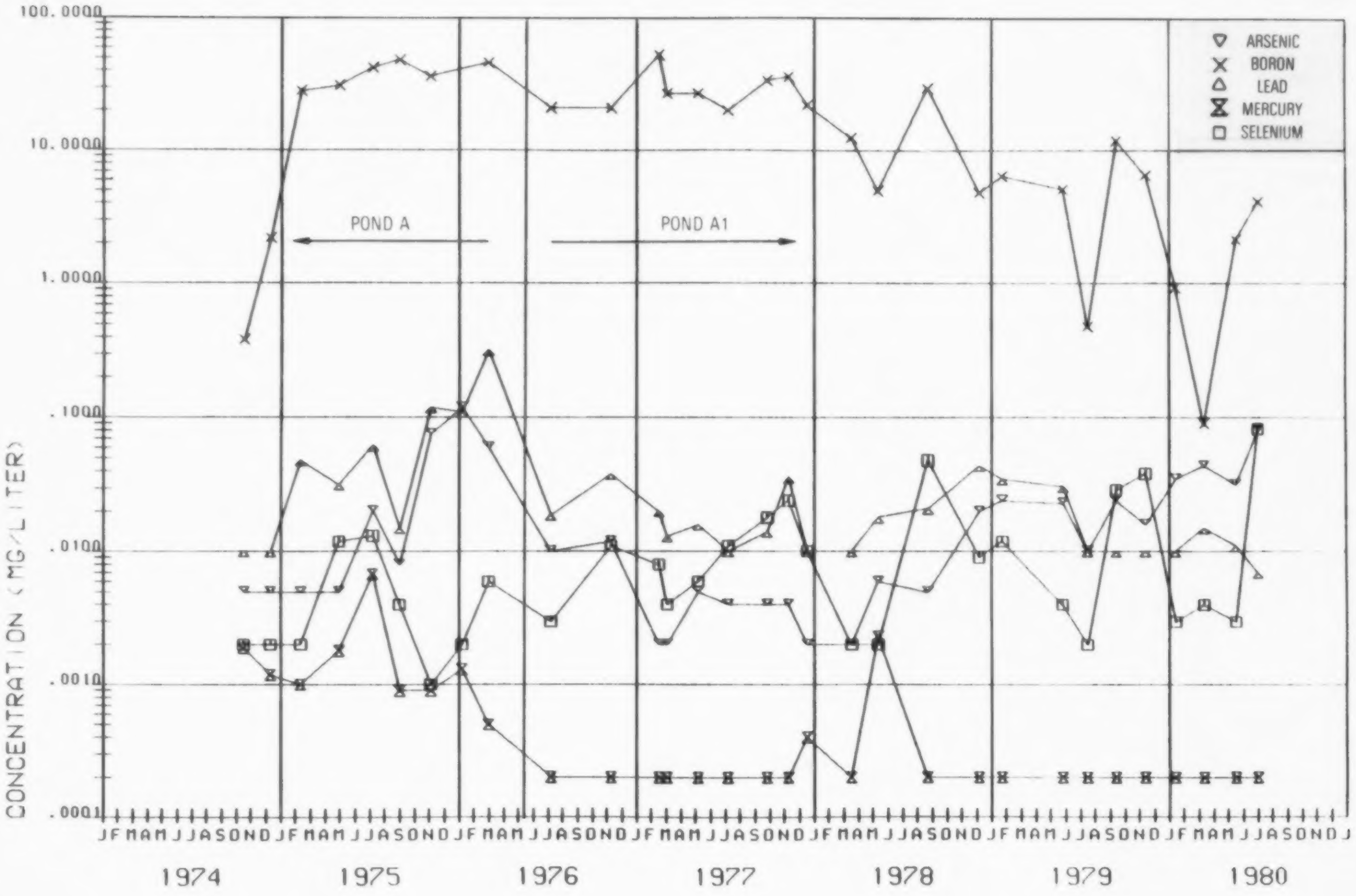


Figure 18. Concentration of minor species in Site A/A1 leachate

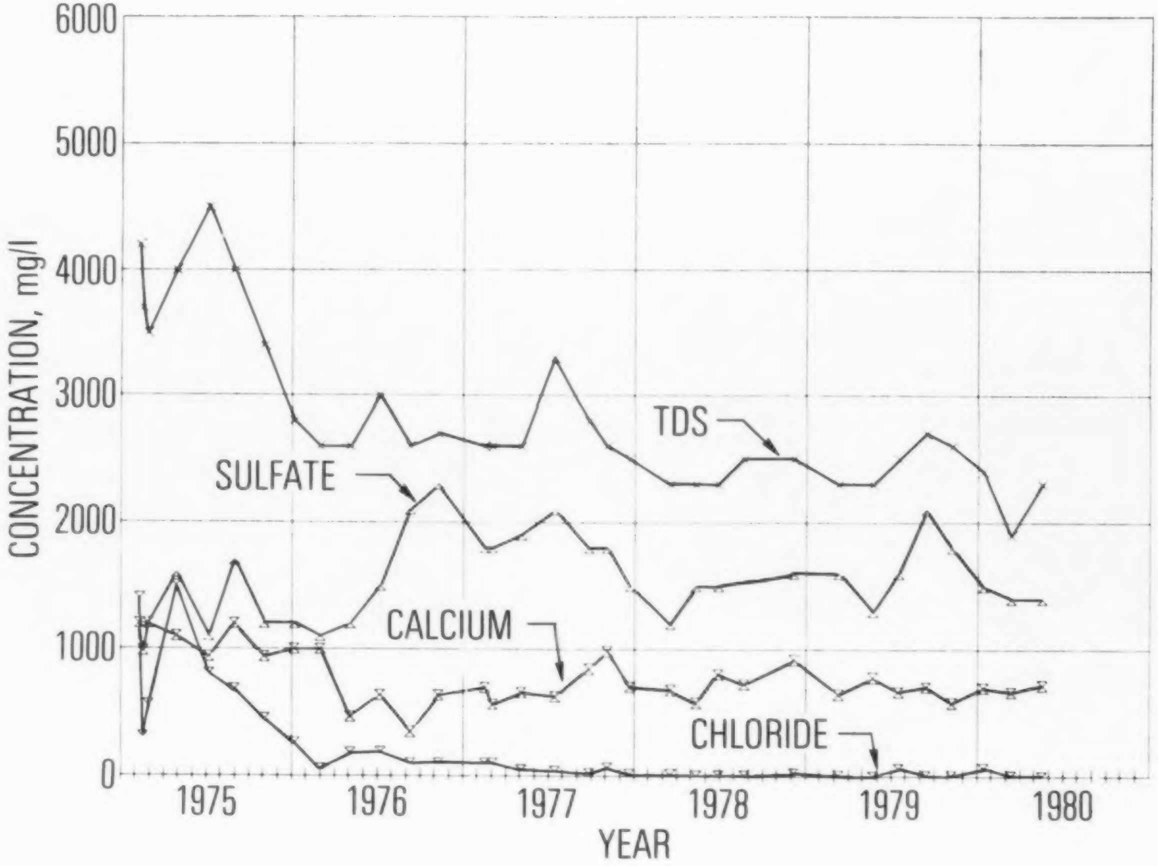


Figure 19. Concentration of TDS and major species in Site D leachate

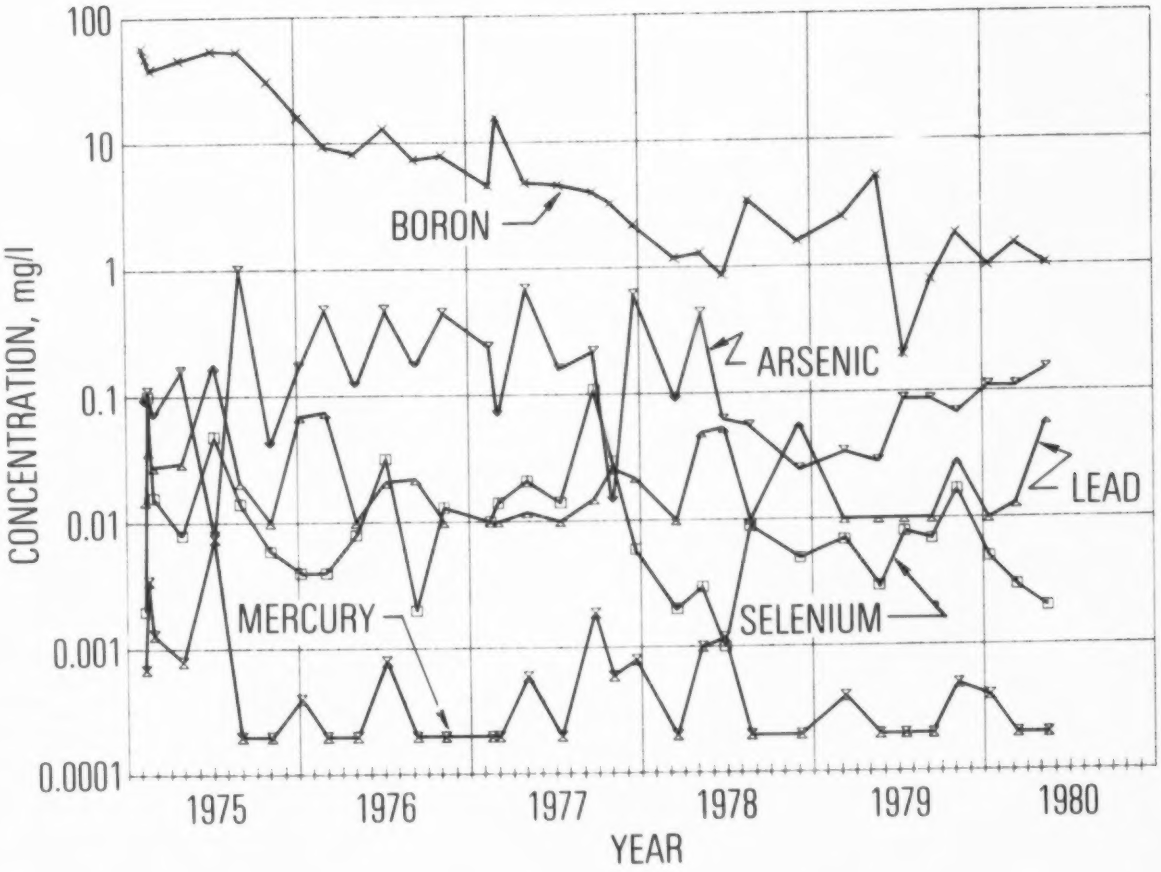


Figure 20. Concentration of minor species in Site D leachate

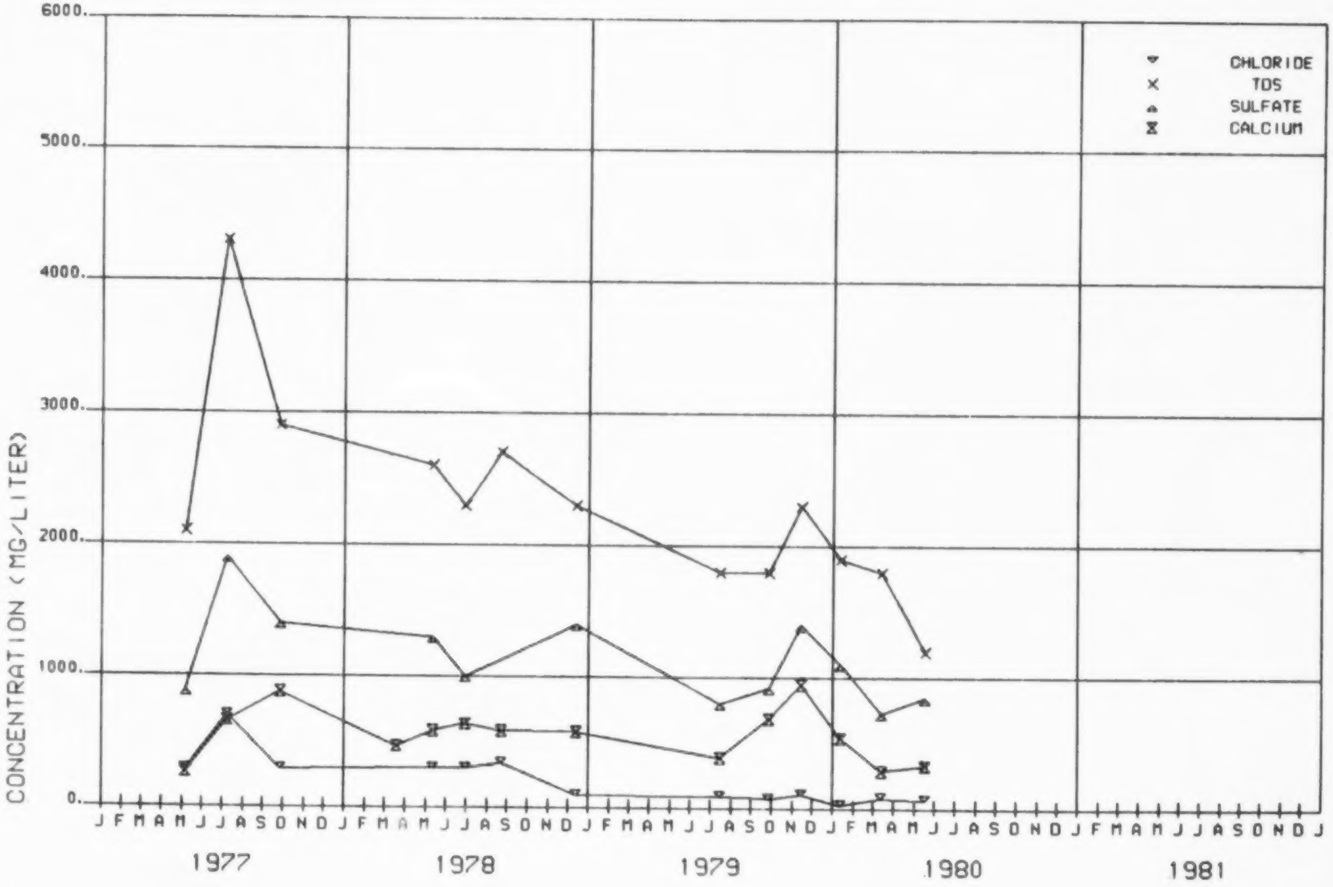


Figure 21. Concentration of TDS and major species in Site G underdrain

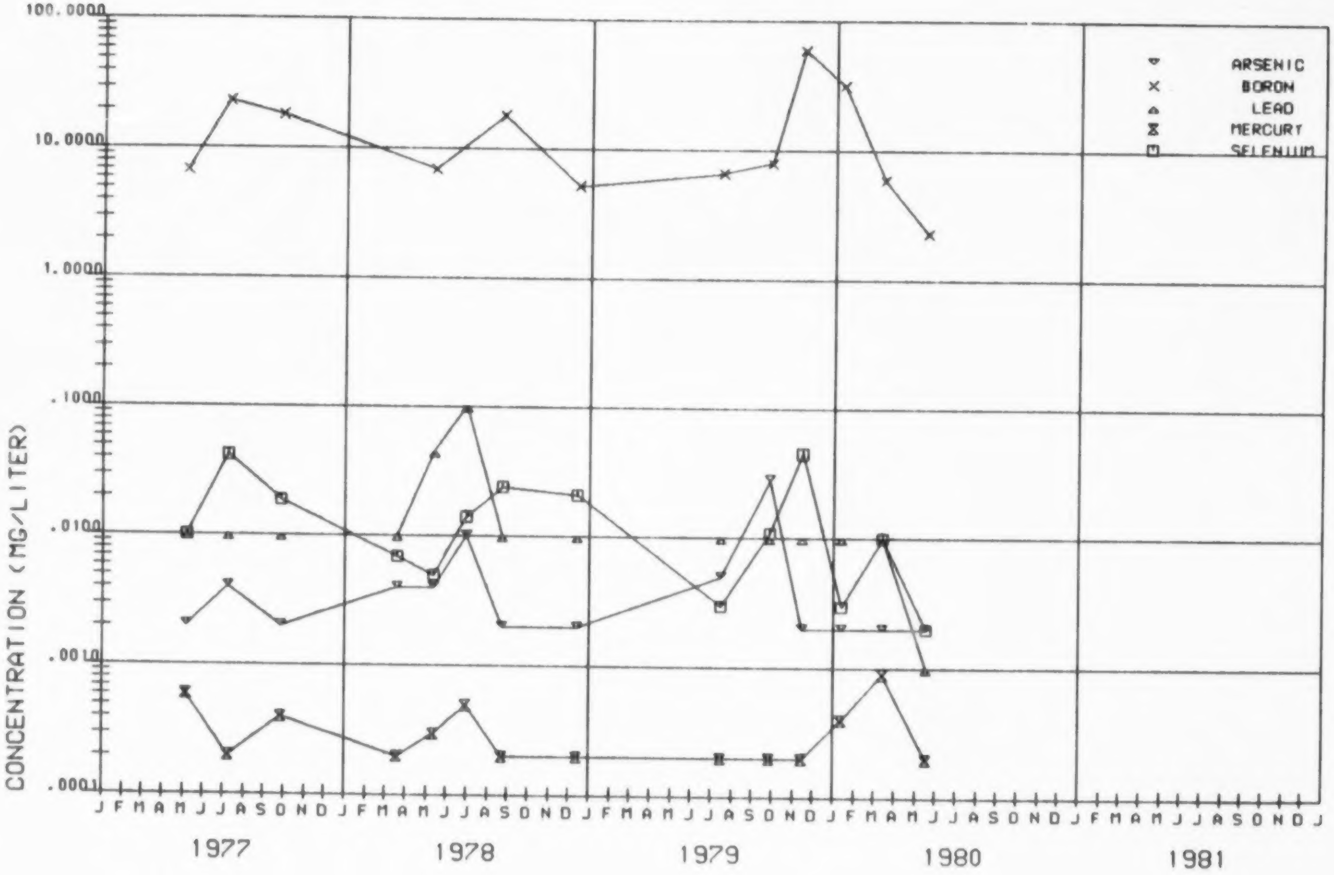


Figure 22. Concentration of minor species in Site G underdrain

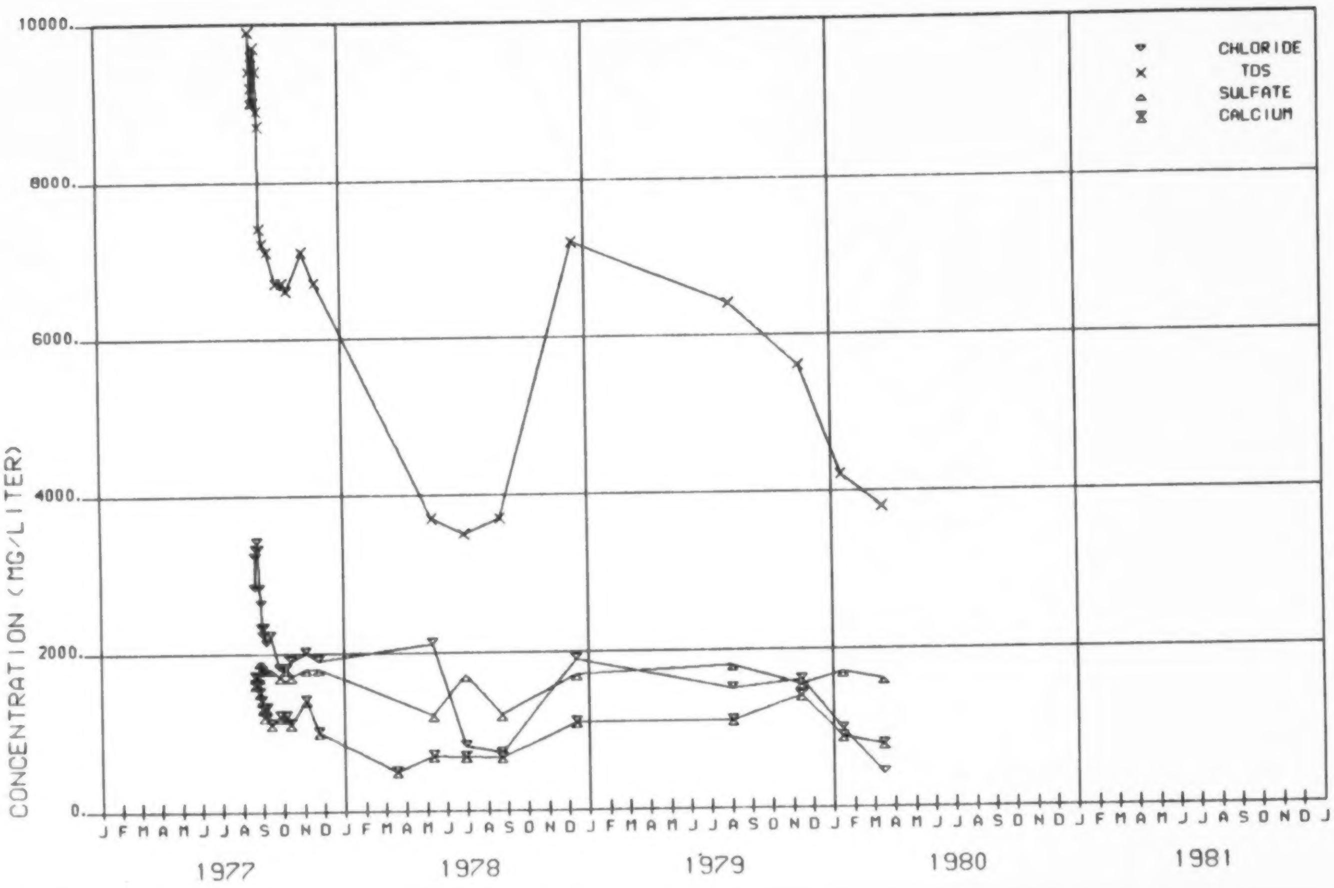


Figure 23. Concentration of TDS and major species in Site H Underdrain

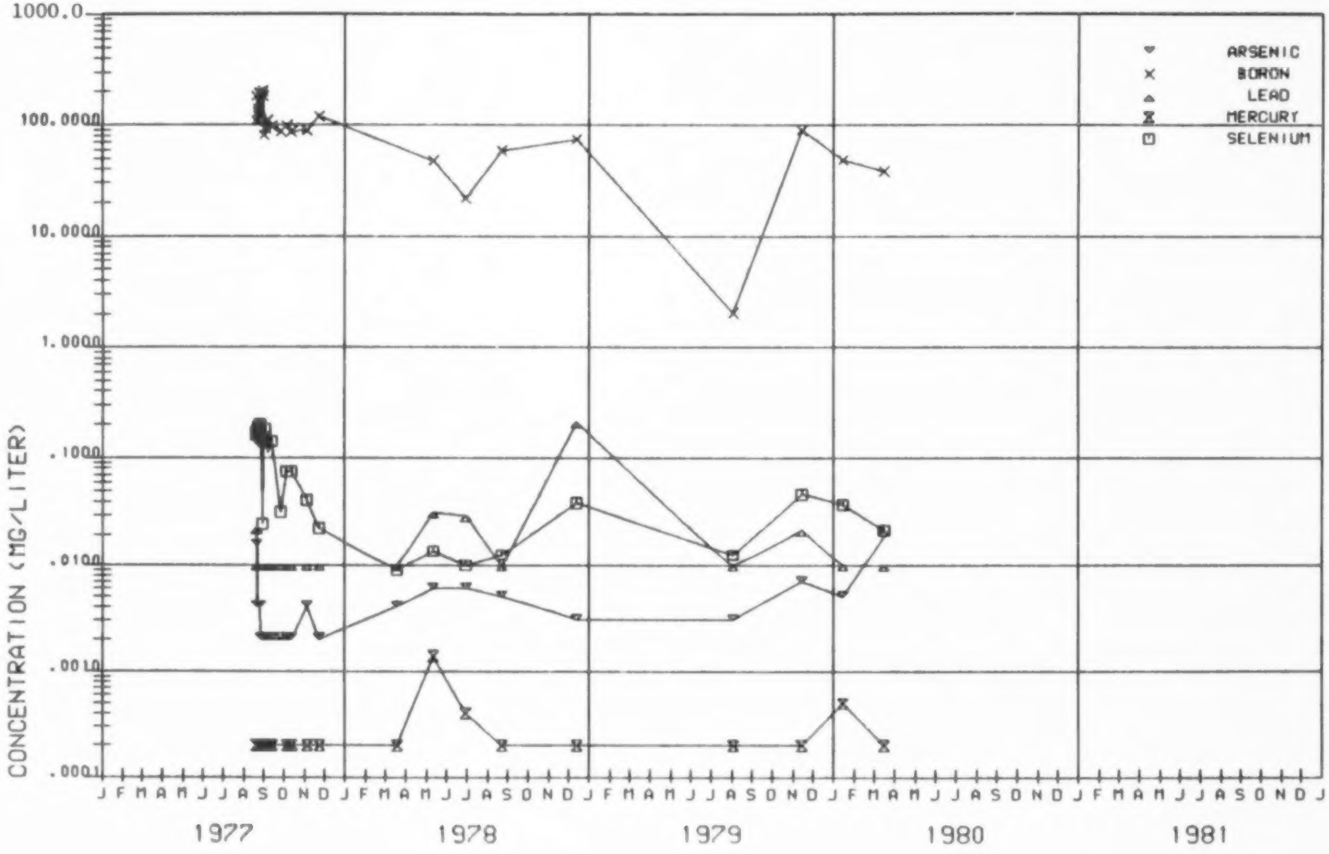


Figure 24. Concentration of minor species in Site H underdrain

The complete chemical characterization of the untreated waste input and leachate is given for Sites A, D, F, G, and H in Tables 20 through 24. These analyses include the trace elements that were analyzed periodically, such as aluminum, chromium, iron, silver, and zinc. Analyses were identified by sampling data, in months, after the site was filled. Trends in the concentration of the major and minor species discussed earlier are reported here for completeness. Generally, there were no large variations in the concentrations. As noted earlier, the major species (TDS, calcium, sulfate, and chloride) decreased in concentration with time. The minor species, now including a variety of trace elements, show somewhat larger variations in concentration, and generally little decrease in concentration with time. A close inspection of the data shows that none of the analyses indicates concentrations greater than 100 times the National Interim Primary Drinking Water Regulations. Although temporarily exempt from the Hazardous Waste Management System, concentrations of less than 100 times that of species included in these regulations would classify these wastes as nonhazardous (Section 5.4.3).

Chemically Treated Wastes

The chemical composition of the leachate from the chemically treated waste show that the initial values of the major species were nearly half of the input values. Generally there was little, if any, reduction of major species in the leachate with time. Site B (Dravo treatment) showed relatively constant values for TDS and calcium, with a slight increase in sulfate and a decrease in chloride (Figure 25). The TDS concentration appears to vary around 2300 mg/l. Site C (IU Conversion Systems treatment) showed a larger decrease in TDS, calcium, and chloride, with a significant increase in sulfate (Figure 26). The TDS concentration appears to have leveled to a value of 2300 mg/l. In contrast, Site E (Chemfix treatment) appears to have had a slight increase in TDS, calcium, and sulfate prior to capping of the site with clay material (Figure 27). Chloride, as before, decreased in concentration with time. For minor species, the chemically treated sites (Figures 28 through 30) show characteristics similar to the untreated waste. On this basis, it has been concluded that the chemical treatment has not significantly reduced the concentration of the minor species in the leachate.

The chemical characterization of the chemically treated FGD wastes is given in Tables 25 through 27. In general, these analyses show similar characteristics in the trends in the concentration of the trace elements. As seen in the data, none of the minor species or trace elements analyses show a concentration of greater than 100 times the National Interim Primary Drinking Water Regulations.

5.2.2 Runoff

Water analysis has been conducted on runoff samples taken from chemically treated Site C and gypsum Sites H and J. The runoff samples in Site C showed an average value of 1700 mg/l for TDS, with a temporary decrease in concentration to approximately 1100 mg/l in November 10, 1979 (Figure 31).

TABLE 20. CHEMICAL CHARACTERIZATION OF SITE A WASTE INPUT AND LEACHATE

SAMPLE[a]	INPUT	LEACHATE	LEACHATE	LEACHATE
Months After Filling		12	22	42
Aluminum	--	4.3	12.9	3.1
Antimony	--	0.12	0.47	0.12
Arsenic	0.024	< 0.001	0.037	0.010
Barium	--	1.5	< 0.5	<0.2
Boron	44	25	12.5	6.0
Cadmium	--	0.040	0.006	0.007
Calcium	2100	860	470	395
Chloride	4600	780	195	200
Chromium	--	0.026	0.01	0.08
Cobalt	--	<0.05	<0.1	<0.1
Copper	--	0.03	< 0.10	<0.1
Fluoride	--	2.3	5	--
Iron	--	<0.05	< 0.1	<0.1
Lead	0.49	0.02	0.01	0.06
Magnesium	290	50	24	50.4
Manganese	--	1.5	<0.5	<0.1
Mercury	< 0.0001	< 0.0002	0.0011	0.0006
Molybdenum	--	0.47	<0.1	<0.3
Nickel	--	< 0.01	<0.1	<0.1
Nitrogen (total)	--	2.1	1.7	0.7
Potassium	--	15.5	18	--
Selenium	0.005	0.006	0.0003	0.007
Silicon (SiO_2)	--	0.80	5.4	40
Silver	--	0.013	<0.5	<0.1
Sodium	--	48	10	5.2
Tin	--	0.01	<0.1	<1.0
Vandium	--	0.42	< 0.05	<0.01
Zinc	--	<0.05	0.5	<0.1
Alkalinity (total)	61	41	25	61.6
Carbonate	--	<20	37	79.3
COD	--	23	13	16
Conductivity	12000	3100	2110	2100
pH	8.3	7.2	7.3	7.2
Sulfate	1530	1300	1310	1500
TDS	8560	3140	2170	2300
TSS	--	59	7	14

[a] All units in mg/l except for Conductivity (μmhos/cm at 25°C) and pH (dimensionless)

-- Not determined

TABLE 21. CHEMICAL CHARACTERIZATION OF SITE D WASTE INPUT AND LEACHATE

SAMPLE [a]	INPUT	LEACHATE	LEACHATE	LEACHATE	LEACHATE	LEACHATE
Months After Filling		9	25	35	47	55
Aluminum	--	3.8	4.5	10.3	3	3.6
Antimony	--	0.40	0.08	0.46	0.72	0.13
Arsenic	0.24	0.34	0.7	0.25	< 0.01	0.009
Barium	--	--	2.5	0.8	2.5	<0.2
Boron	93	16	4.8	2.6	0.7	1.5
Cadmium	—	<0.002	0.027	0.006	0.015	0.005
Calcium	1880	675	660	460	460	450
Chloride	2950	970	180	15	20	17
Chromium	—	0.11	0.026	0.01	<0.03	0.08
Cobalt	—	<0.05	<0.05	<0.1	<0.1	<0.1
Copper	—	<0.05	<0.007	0.10	<0.1	<0.1
Fluoride	--	3.0	1.5	1.8	—	—
Iron	—	0.10	0.25	<0.1	<0.1	<0.1
Lead	<0.02	<0.01	0.012	0.01	<0.01	<0.06
Magnesium	50	37	14	8.8	5.0	4.3
Manganese	—	<0.05	<0.01	<0.5	<0.1	<0.1
Mercury	0.0003	0.0012	0.00033	0.0002	<0.005	0.001
Molybdenum	—	0.34	0.16	<0.1	<0.1	<0.3
Nickel	—	<0.05	0.015	<0.1	<0.1	<0.1
Nitrogen (total)	—	0.74	0.7	0.9	140	0.8
Potassium	51	13	12.5	5.7	--	--
Selenium	0.014	0.004	0.0013	0.002	0.012	0.008
Silicon (SiO_2)	—	0.48	0.90	6.0	106	54
Silver	—	0.012	0.005	<0.5	<0.05	<0.1
Sodium	56	17	10.2	7.0	8.8	4.6
Tin	--	<0.08	<0.01	<0.1	<1.0	<1.0
Vandium	—	0.08	0.42	<0.05	<4	<0.01
Zinc	--	<0.05	<0.02	0.1	<0.05	<0.1
Alkalinity (total)	303	68	<2	--	1.0	43
Carbonate	6	<1.0	<1.0	<3.0	10	134
COD	130	50	36	44	82	180
Conductivity	7140	2740	2360	2070	1960	1980
pH	9.2	7.8	5.3	4.2	7.2	6.2
Sulfate	1500	1380	1630	1400	1580	1400
TDS	6750	2970	2400	2160	2180	2460
TSS	--	220	100	1600	470	640

[a] All units in mg/l except for Conductivity (μmhos/cm at 25°C) and pH (dimensionless)

— Not determined

TABLE 22. CHEMICAL CHARACTERIZATION OF SITE F WASTE INPUT AND UNDERDRAINAGE

SAMPLE [a]	INPUT	UNDERDRAIN [b]	UNDERDRAIN [b]	UNDERDRAIN [b]
Months After Filling		3	13	25
Aluminum	--	6.4	--	4.5
Antimony	--	3.12	--	0.91
Arsenic	0.002	<0.001	0.008	<0.01
Barium	--	<1.0	--	4.0
Boron	76	9.0	1.3	12
Cadmium	---	0.040	--	0.02
Calcium	1990	940	200	660
Chloride	2000	980	250	1150
Chromium	--	0.040	--	<0.03
Cobalt	--	<0.05	--	<0.1
Copper	--	0.05	--	<0.1
Fluoride	<1	2.1	<1	--
Iron	--	0.05	--	<0.1
Lead	<0.01	0.01	0.01	0.01
Magnesium	0.3	1.8	52	62.0
Manganese	---	<0.01	--	0.77
Mercury	<0.0002	<0.0002	<0.0001	0.007
Molybdenum	--	1.32	--	1.0
Nickel	--	0.01	--	0.27
Nitrogen (total)	--	1.4	--	35
Potassium	204	54	59	--
Selenium	0.042	0.027	<0.002	0.002
Silicon (SiO_2)	--	0.80	--	86
Silver	--	0.013	--	<0.05
Sodium	70	51	90	62
Tin	--	<0.01	--	<1
Vandium	--	0.42	--	<4
Zinc	--	<0.05	--	0.10
Alkalinity (total)	--	44	200	48
Carbonate	--	<25	--	<44
COD	43	33	25	23
Conductivity	6940	4130	1480	4030
pH	12.2	9.9	7.7	7.1
Sulfate	1100	1230	430	1430
TDS	6700	3340	1180	3580
TSS	--	12	--	89

[a] All units in mg/l except for Conductivity (µmhos/cm at 25°C) and pH (dimensionless)

-- Not determined

[b] Underdrain sample taken after pond was covered (11-11-77).

TABLE 23. CHEMICAL CHARACTERIZATIN OF SITE G WASTE INPUT AND UNDERDRAINAGE

SAMPLE [a]	INPUT	UNDERDRAIN	UNDERDRAIN	UNDERDRAIN	UNDERDRAIN
Months After Filling		7	19	31	40
Aluminum	--	2.4	--	--	--
Antimony	--	0.23	--	--	--
Arsenic	0.14	0.014	0.008	0.05	0.02
Barium	--	2.0	--	--	--
Boron	93	6.7	23	11	18
Cadmium	--	--	--	--	--
Calcium	150	390	600	420	380
Chloride	3600	385	930	125	130
Chromium	--	0.013	--	--	--
Cobalt	--	<0.05	--	--	--
Copper	--	0.07	--	--	--
Fluoride	--	1.2	2.5	--	--
Iron	--	0.05	--	--	--
Lead	<0.01	0.01	0.01	0.01	0.03
Magnesium[c]	5000	103	217	48	65
Manganese	--	0.35	--	--	--
Mercury	<0.0002	<0.00006	0.001	0.0013	0.00013
Molybdenum	--	0.16	--	--	--
Nickel	--	0.025	--	--	--
Nitrogen (total)	--	0.8	--	--	--
Potassium	--	19	56	--	--
Selenium	0.63	0.0017	0.0004	0.008	0.007
Silicon (SiO_2)	--	0.90	--	--	--
Silver	--	0.008	--	--	--
Sodium	12	29	25	8.1	15
Tin	--	<0.01	--	--	--
Vandium	--	0.42	--	--	--
Zinc	--	<0.05	--	--	--
Alkalinity (total)	--	175	50	46	67
Carbonate	--	<100	--	--	--
COD	53	15	10	--	2
Conductivity	--	2250	3450	2080	2190
pH	7.8	7.3	7.5	6.9	7.3
Sulfate	6600	900	1480	1160	1200
TDS	14000	1720	3120	2270	2320
TSS	--	4	--	--	5

[a] All units in mg/l except for Conductivity (µmhos/cm at 25°C) and pH (dimensionless)

-- Not determined

[c] Magnesia added to lime absorbent

TABLE 24. CHEMICAL CHARACTERIZATION OF SITE H WASTE INPUT AND LEACHATE

SAMPLE [a]	INPUT	UNDERDRAIN	UNDERDRAIN
Months After Filling		6	18
Aluminum	--	--	4.5
Antimony	--	--	0.91
Arsenic	<0.003	0.012	<0.01
Barium	--	--	3.4
Boron	120	36	57
Cadmium	--	--	0.025
Calcium	1300	490	580
Chloride	3500	1350	1450
Chromium	--	--	<0.03
Cobalt	--	--	<0.1
Copper	--	--	<0.1
Fluoride	<1.0	2.0	--
Iron	--	--	<0.1
Lead	<0.01	<0.01	0.15
Magnesium	540	298	372
Manganese	--	--	1.20
Mercury	<0.0002	0.0017	0.006
Molybdenum	--	--	<1.0
Nickel	--	--	<0.1
Nitrogen (total)	--	--	1050
Potassium	42	25	--
Selenium	0.14	0.0003	0.020
Silicon (SiO_2)	--	--	142
Silver	--	--	<0.05
Sodium	62	55	38
Tin	--	--	<1
Vandium	--	--	<4
Zinc	--	--	0.07
Alkalinity (total)	54	279	84
Carbonate	--	--	82
COD	130	--	--
Conductivity	10500	3600	5050
pH	7.1	7.7	6.6
Sulfate	1930	1030	1150
TDS	9200	2930	4260
TSS	35	--	--

[a] All units in mg/l except for Conductivity (µmhos/cm at 25°C) and pH (dimensionless). underdrain system used for sampling only.

-- Not determined

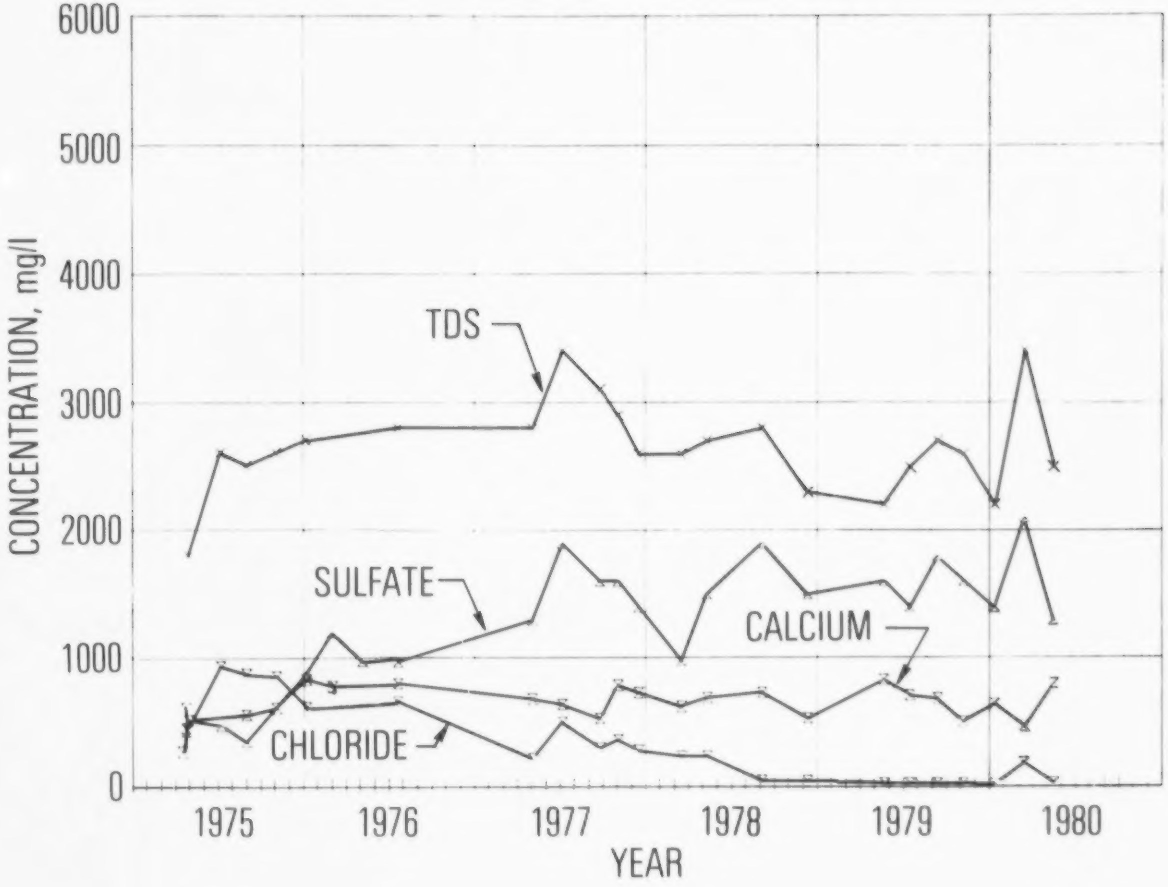


Figure 25. Concentration of TDS and major species in Site B leachate

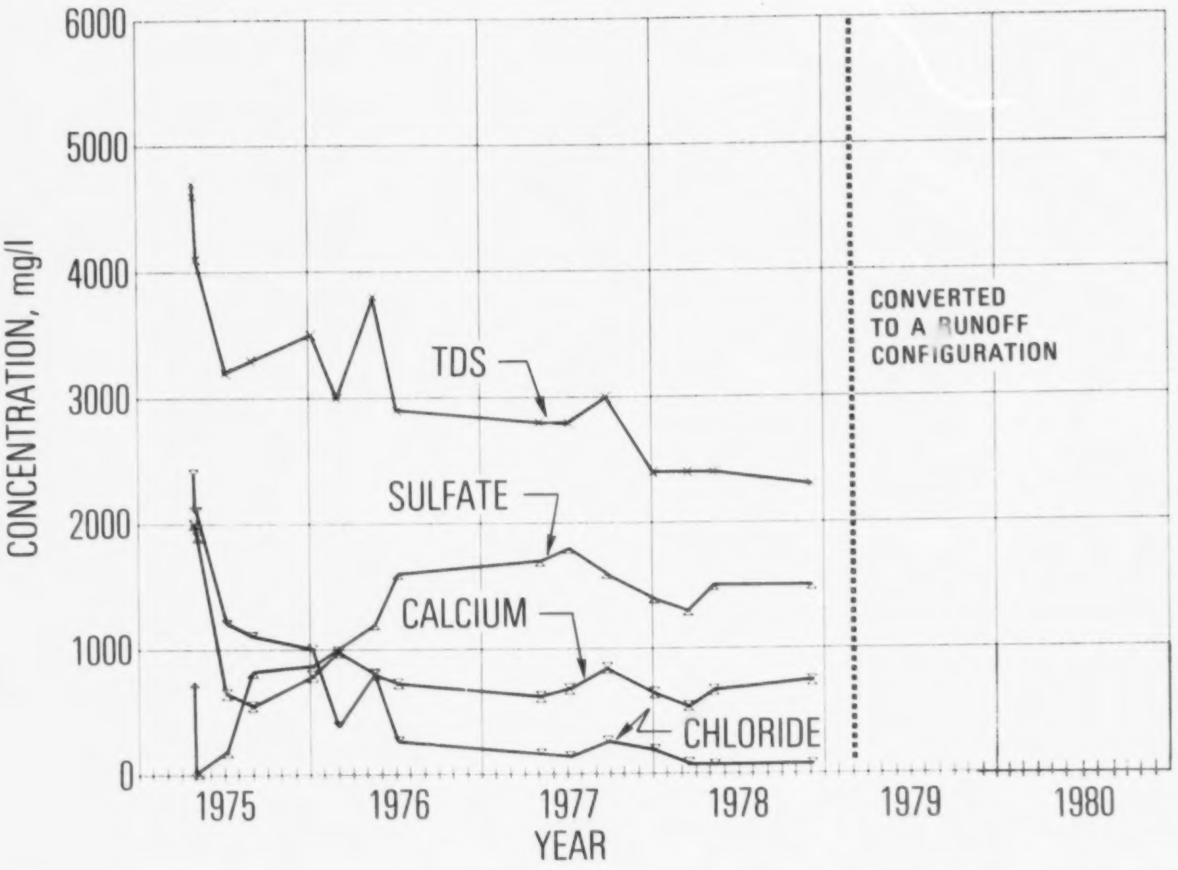


Figure 26. Concentration of TDS and major species in Site C leachate

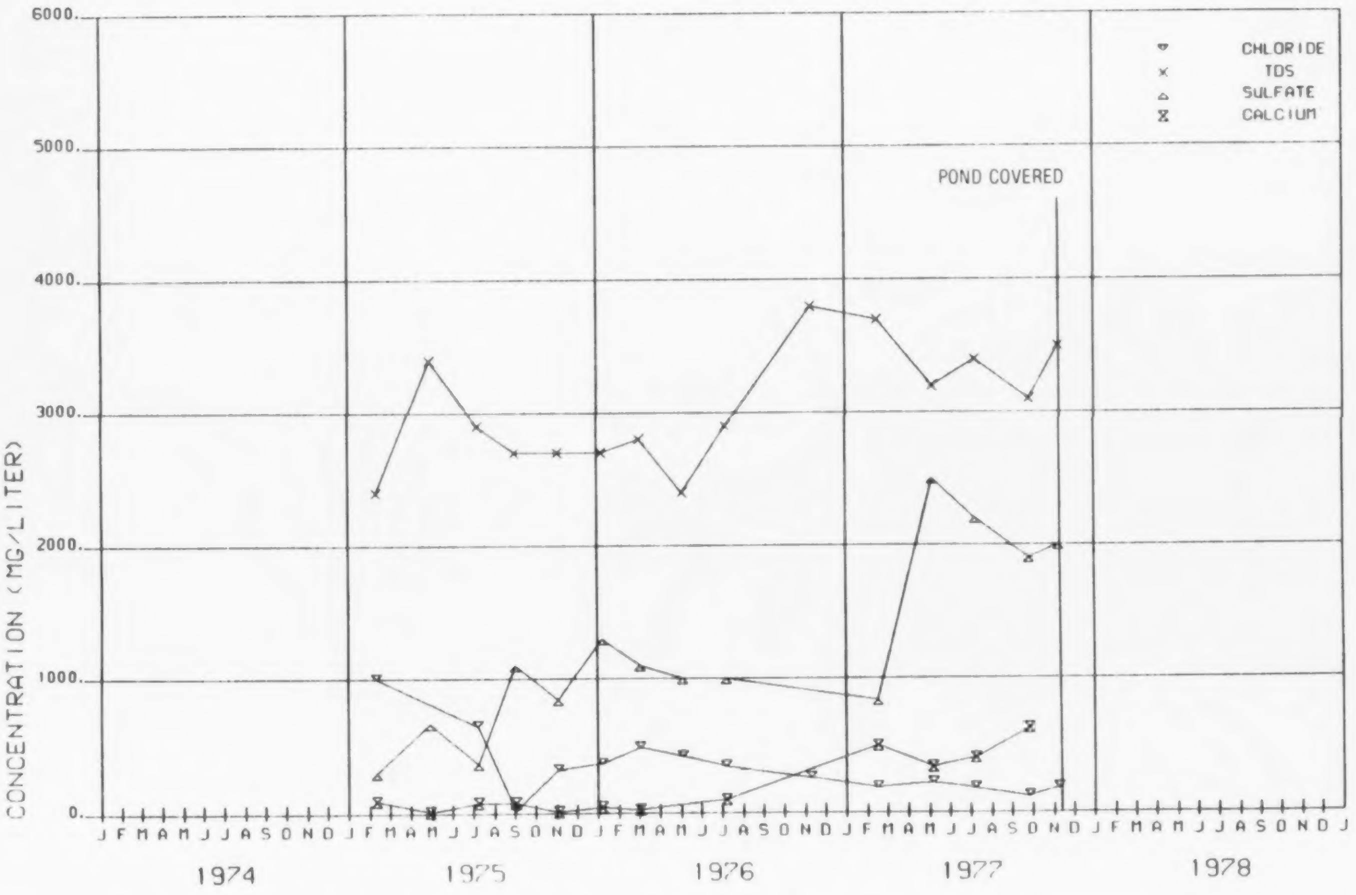


Figure 27. Concentration of TDS and major species in Site E leachate

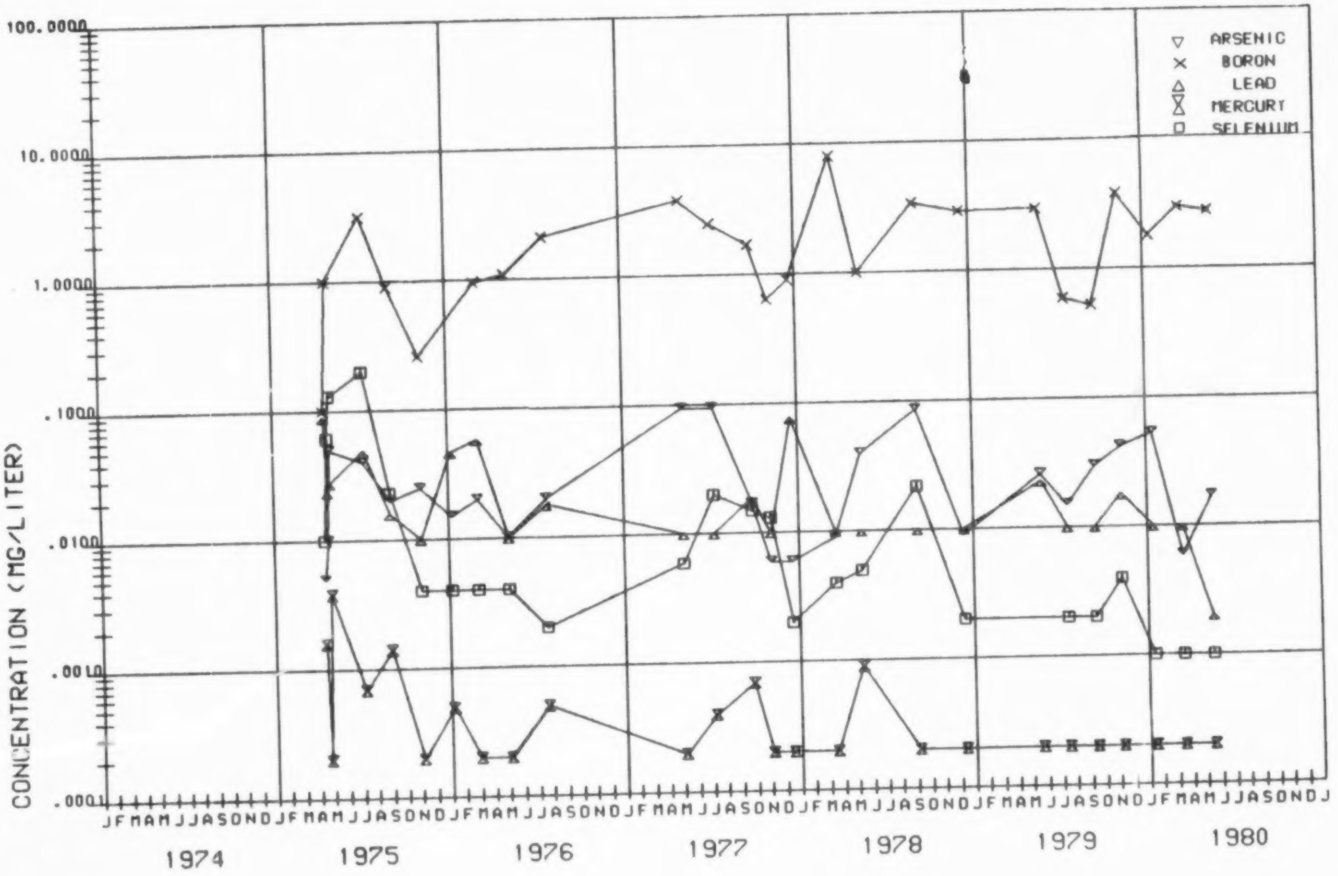


Figure 28. Concentration of minor species in Site B leachate

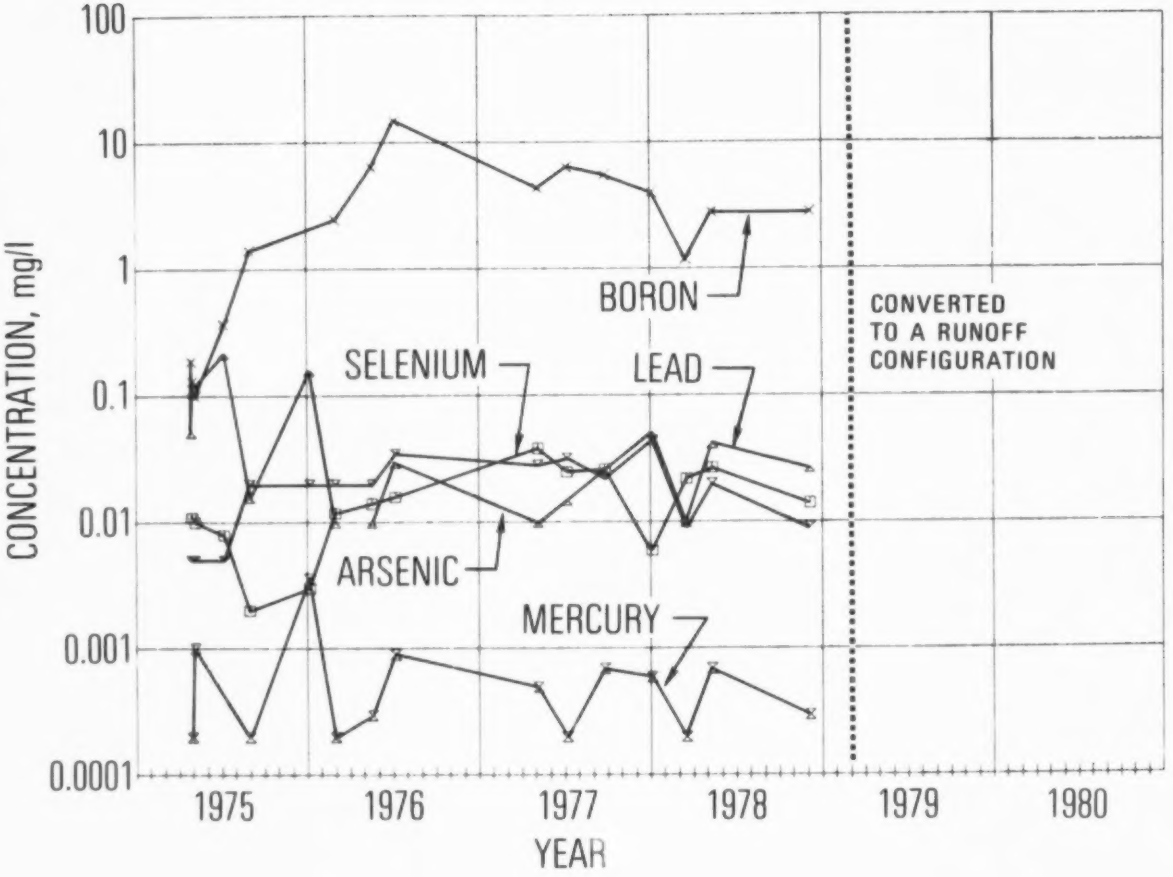


Figure 29. Concentration of minor species in Site C leachate

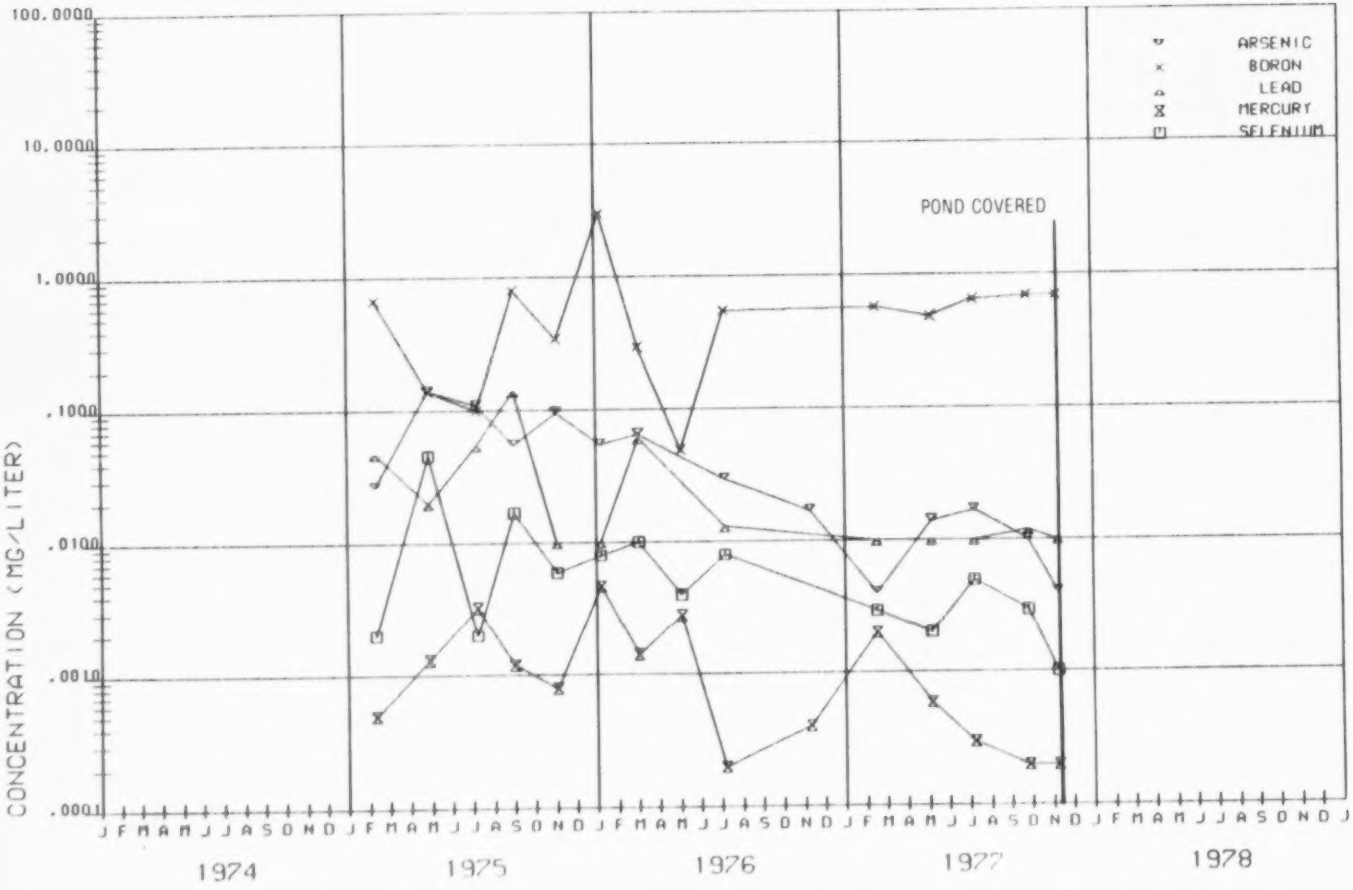


Figure 30. Concentration of minor species in Site E leachate

TABLE 25. CHEMICAL CHARACTERIZATION OF SITE B WASTE INPUT AND LEACHATE

SAMPLE [a]	INPUT	LEACHATE	LEACHATE	LEACHATE	LEACHATE
Months After Filling		7	23	33	53
Aluminum	--	3.0	4.25	13.4	3.4
Antimony	--	0.18	0.04	0.60	0.09
Arsenic	0.004	0.011	<0.001	0.03	0.008
Barium	--	--	1.0	1.5	<0.2
Boron	97	1.3	1.95	2.1	4.0
Cadmium	--	<0.002	0.030	0.008	0.005
Calcium	1060	525	700	500	405
Chloride	1850	520	275	240	25
Chromium	--	0.02	0.026	0.03	0.08
Cobalt	--	<0.05	<0.05	0.1	<0.1
Copper	--	<0.05	<0.007	0.96	<0.1
Fluoride	--	0.05	1.2	<1	--
Iron	--	0.05	<0.05	<0.1	<0.10
Lead	<0.02	0.01	0.01	0.01	0.08
Magnesium	30	27	12.6	10	13.7
Manganese	--	0.47	0.75	<0.5	0.83
Mercury	0.00024	0.0007	0.0002	0.001	0.007
Molybdenum	--	0.11	0.084	<0.1	<0.3
Nickel	--	<0.05	<0.01	0.3	<0.1
Nitrogen (total)	--	3.61	1.4	1.7	0.7
Potassium	--	109	105	126	--
Selenium	0.020	0.009	0.0017	0.0004	0.007
Silicon (SiO_2)	--	--	0.9	5.4	17
Silver	--	0.022	0.01	<0.5	<0.1
Sodium	17	83	45	50	12
Tin	--	<0.08	<0.01	<0.1	<1
Vandium	--	<0.08	0.21	<0.05	<0.01
Zinc	--	<0.05	<0.05	0.7	<0.1
Alkalinity (total)	76	39	79	--	66
Carbonate	46	<1	<40	<3	85.4
COD	140	50	37	64	7
Conductivity	5300	2700	2400	2570	2080
pH	8.9	7.4	6.7	5.5	6.7
Sulfate	1880	1100	1650	1300	1480
TDS	5160	2540	2620	2420	2400
TSS	--	130	140	110	140

[a] All units in mg/l except for Conductivity (μmhos/cm at 25°C) and pH (dimensionless)

-- Not determined

TABLE 26. CHEMICAL CHARACTERIZATION OF SITE C WASTE INPUT AND LEACHATE

SAMPLE [a]	INPUT	LEACHATE	LEACHATE	LEACHATE
Months After Filling		7	23	33
Aluminum	--	2.6	4.0	11.3
Antimony	—	0.12	<0.04	0.28
Arsenic	0.002	0.021	0.018	0.033
Barium	—	--	1.0	<0.5
Boron	34	1.0	2.8	2.6
Cadmium	--	<0.002	0.028	0.003
Calcium	2720	575	690	450
Chloride	4700	1050	205	54
Chromium	—	0.03	0.020	0.02
Cobalt	—	<0.05	<0.05	0.1
Copper	—	<0.05	<0.007	0.10
Fluoride	—	0.4	0.8	<1
Iron	—	0.18	<0.05	<0.1
Lead	<0.01	<0.01	0.01	0.01
Magnesium	33	9.0	7.0	11
Manganese	--	0.19	<0.01	<0.5
Mercury	<0.0001	0.0012	0.0005	<0.0001
Molybdenum	—	0.45	0.35	<0.1
Nickel	--	<0.05	<0.01	<0.1
Nitrogen (total)	--	<0.01	<0.1	0.45
Potassium	—	425	155	88
Selenium	0.018	0.022	0.038	0.022
Silicon (SiO_2)	--	0.48	0.90	6.0
Silver	—	0.038	0.008	<0.5
Sodium	46	143	26	15
Tin	--	0.08	<0.01	<0.1
Vandium	—	<0.08	0.42	<0.05
Zinc	—	<0.05	<0.02	0.2
Alkalinity (total)	111	39	30	17
Carbonate	—	<20	<15	33
COD	140	62	10	8
Conductivity	11000	4160	2400	2060
pH	8.9	6.9	6.9	7.2
Sulfate	1580	1180	1680	1350
TDS	9240	3540	2610	2160
TSS	73	370	53	47

[a] All units in mg/l except for Conductivity (μ mhos/cm at 25°C) and pH (dimensionless)

— Not determined

TABLE 27. CHEMICAL CHARACTERIZATION OF SITE E WASTE INPUT AND LEACHATE

SAMPLE [a]	INPUT	LEACHATE	LEACHATE	LEACHATE[b]	LEACHATE[b]
Months After Filling		13	29	39	51
Aluminum	--	0.2	2.13	--	2.5
Antimony	--	0.10	0.27	--	0.72
Arsenic	0.004	0.076	0.009	.022	< 0.01
Barium	--	--	1.0	--	2.2
Boron	80	0.5	0.5	<0.5	1.2
Cadmium	--	< 0.002	0.031	--	0.02
Calcium	1880	30	360	460	420
Chloride	2700	520	295	195	300
Chromium	--	0.01	0.079	--	0.03
Cobalt	--	< 0.05	< 0.05	--	<0.1
Copper	--	< 0.05	<0.007	--	<0.1
Fluoride	--	1.75	<0.5	< 1	--
Iron	--	0.20	<0.05	--	<0.1
Lead	<0.01	< 0.01	0.01	0.078	<0.1
Magnesium	12	4.0	11.0	34	26.0
Manganese	--	< 0.05	<0.01	--	0.27
Mercury	0.00033	0.0007	0.0006	0.0004	< 0.005
Molybdenum	--	0.32	0.16	--	<0.1
Nickel	--	<0.05	<0.01	--	<0.1
Nitrogen (total)	--	0.52	1.1	--	35
Potassium	--	425	405	340	--
Selenium	0.014	0.005	0.002	<0.002	0.008
Silicon (SiO_2)	--	0.60	0.90	--	140
Silver	--	0.010	0.008	--	<0.05
Sodium	41	540	395	445	340
Tin	--	0.08	0.01	--	< 1
Vandium	--	0.29	0.31	--	< 4
Zinc	--	<0.05	< 0.05	--	0.46
Alkalinity (total)	302	79	26	74	78
Carbonate	--	<50	< 15	--	72
COD	110	60	17	--	67
Conductivity	7140	3330	3550	3910	3570
pH	9.4	8.1	6.8	7.5	7.0
Sulfate	1400	1080	1880	2100	1930
TDS	6190	2640	3160	3880	3550
TSS	--	980	14	160	320

[a] All units in mg/l except for Conductivity (μmhos/cm at 25°C) and pH (dimensionless)

[b] Leachate sample taken after pond was covered (11/11/77)

-- Not determined

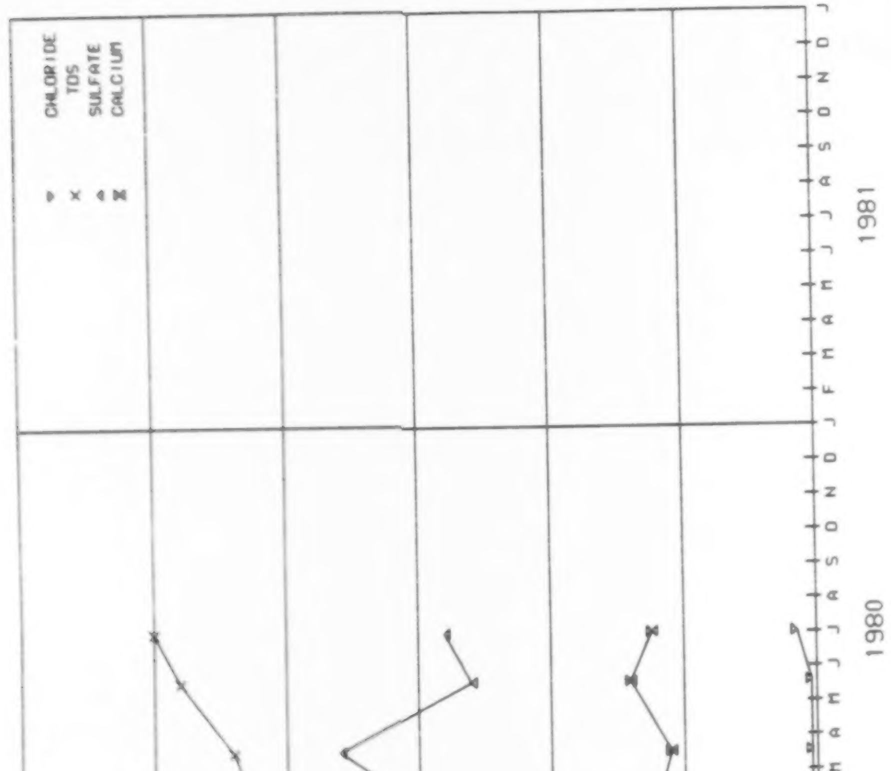


Figure 31. Concentration of TDS and major species in Site C runoff

While the calcium and sulfate also decreased during this period, the chloride concentration remains at a very low level.

The runoff from gypsum Sites H and J show average TDS concentration of approximately 2000 mg/l. Variations in the concentration of the major species is to be expected as the filter cake material erodes from weathering and fresh material is periodically exposed to rainfall. The concentration of the major species in runoff from Sites H and J are shown in Figures 32 and 33. The minor species in the runoff samples showed the variations in the level of these elements. Figure 34, which plots the minor species for Site H, is typical of the range in values of the gypsum sites.

5.2.3 Supernate

Untreated Wastes

The concentration of dissolved solids and major constituents in the supernate of Site A/A1 were found to fluctuate as a result of rainfall and evaporation, which was typical of supernate in all of the ponds. Over the monitoring period, a gradual decrease of peak values of concentration in TDS and major constituents was observed, and by mid-1978 the TDS concentration dropped to less than 1000 mg/l, as compared to a concentration of close to 6000 mg/l in 1974 shortly after pond filling (Figure 35).

The concentration of TDS and major constituents in the supernate of Site D exhibited seasonal variations characteristically found in other ponds at Shawnee (Figure 36). Since 1974, the peak concentration of TDS in these cycles has gradually diminished (except for one period in mid-1978) and has dropped below 2000 mg/l. Sulfate is the main dissolved constituent at 1000 mg/l, with calcium showing less than 500 mg/l and the chloride virtually depleted.

Analysis of the major species for Sites A/A1 and D show considerable variation in concentrations, probably due to seasonal variation in the water level. As shown in Figure 37 for Site D, concentration of minor species was not significantly different from other water samples.

Chemically Treated Wastes

Immediately after filling, the supernate in Site B had a TDS concentration equivalent to that of the input liquor, after which the TDS concentrations of associated dissolved constituents fluctuated as the quantity of supernate increased or decreased as a result of rainfall (Figure 38). Sulfate is the major dissolved constituent, followed by calcium. Chloride was virtually depleted in the supernate approximately one year after filling.

The supernate in Site C showed similar rainfall-induced trends in the concentration of TDS and major constituents as the other sites prior to the conversion of the site to a runoff configuration. The TDS level reached a peak of approximately 4500 mg/l (one-half the concentration of the input liquor) one year after pond filling. Since that time the concentrations of

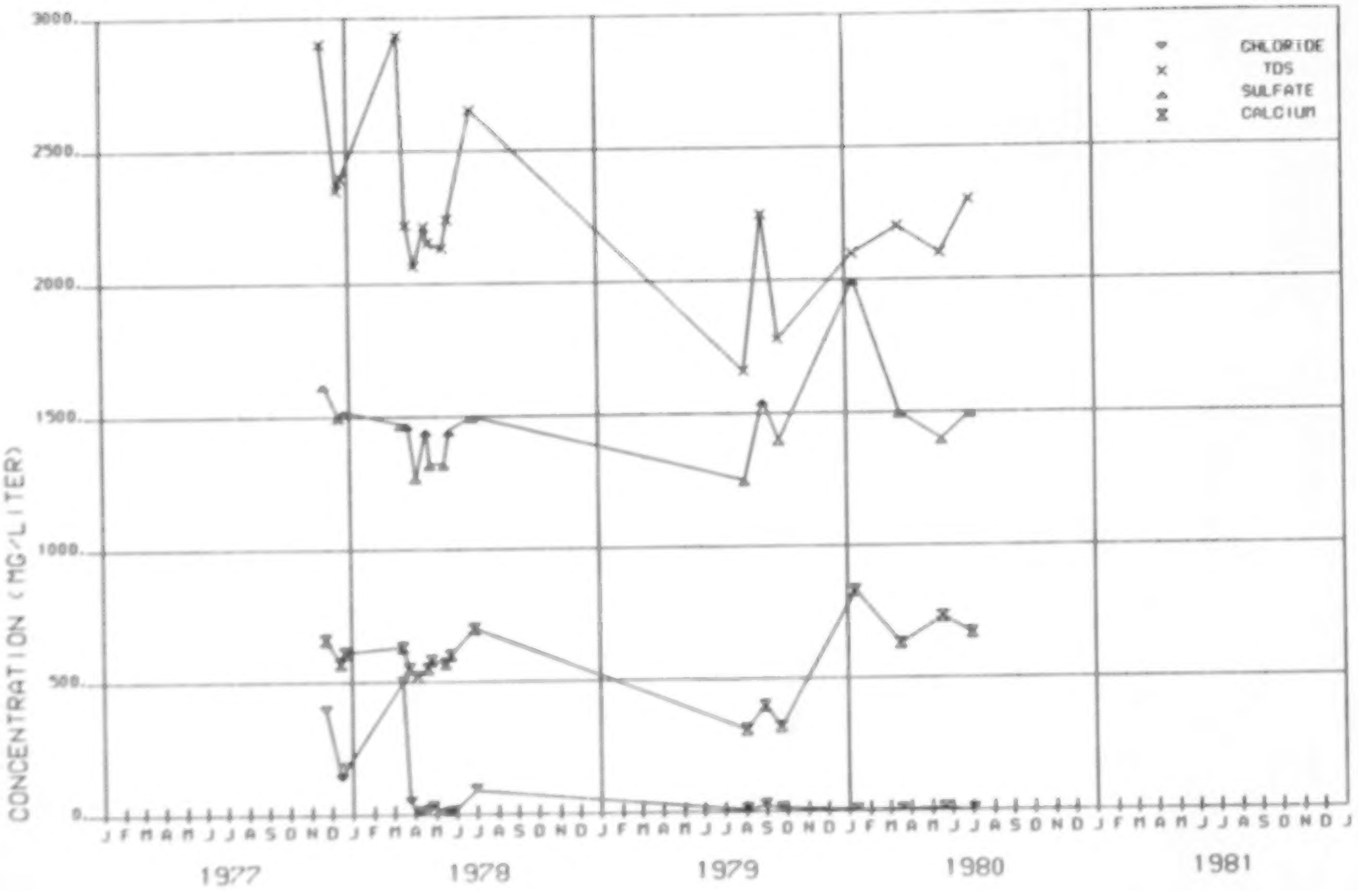


Figure 32. Concentration of TDS and major species in Site H runoff

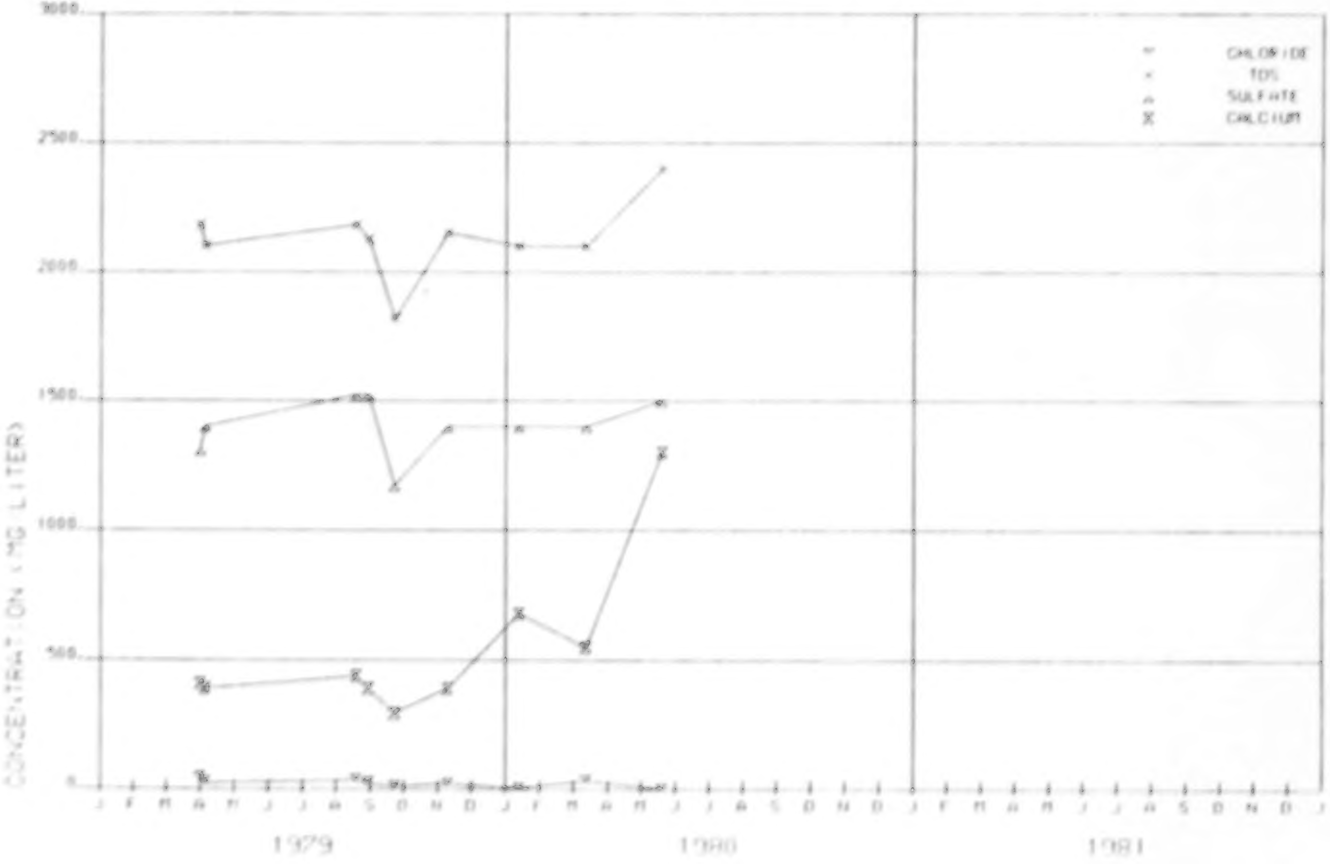


Figure 33. Concentration of TDS and major species in Site J runoff

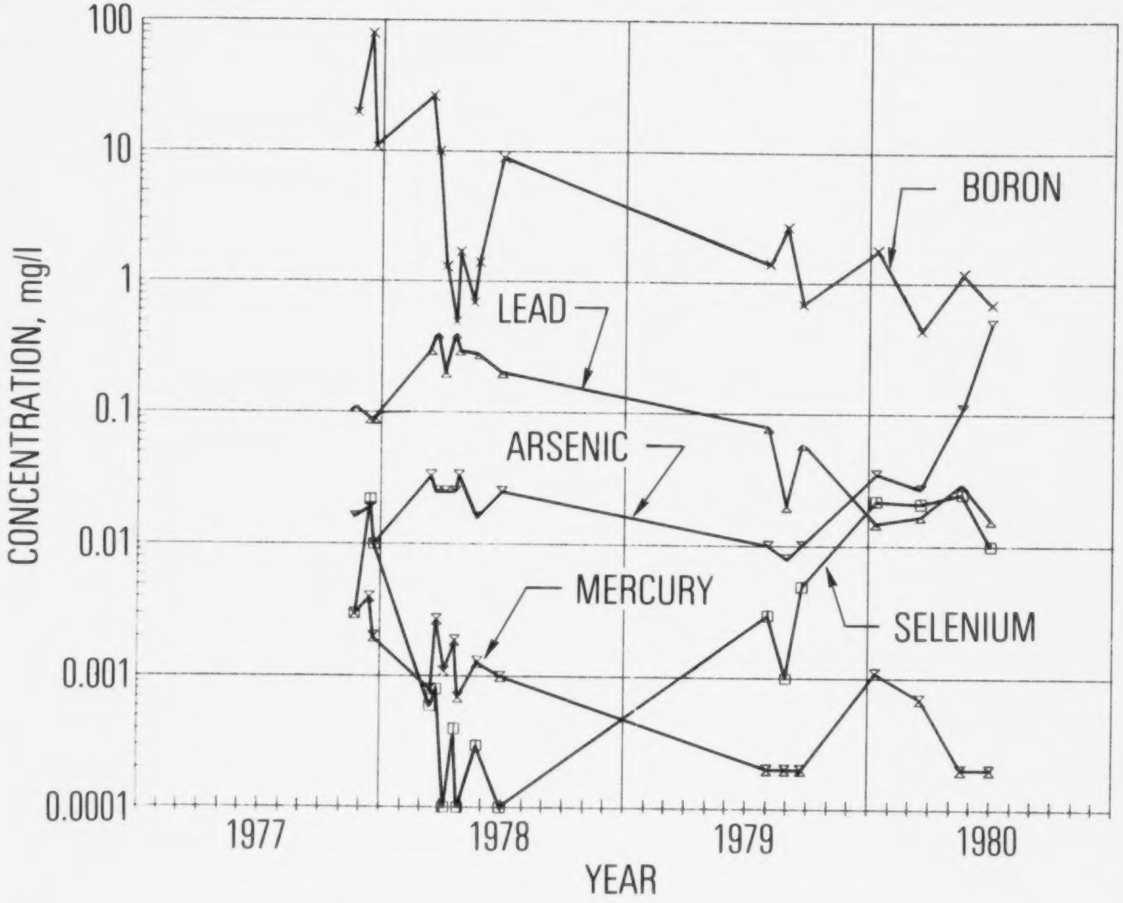


Figure 34. Concentration of minor species in Site H runoff

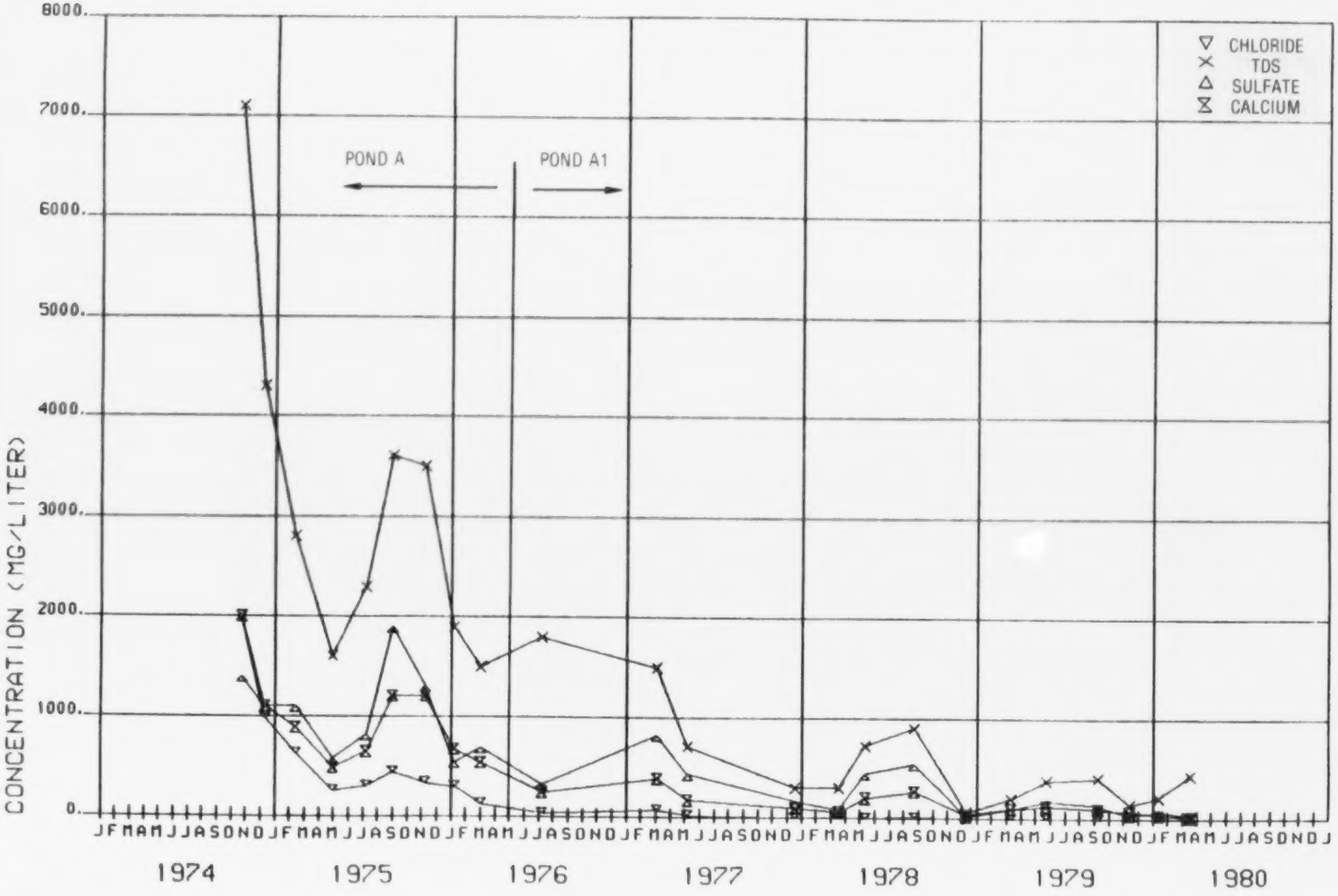


Figure 35. Concentration of TDS and major species in Site A/A1 supernate

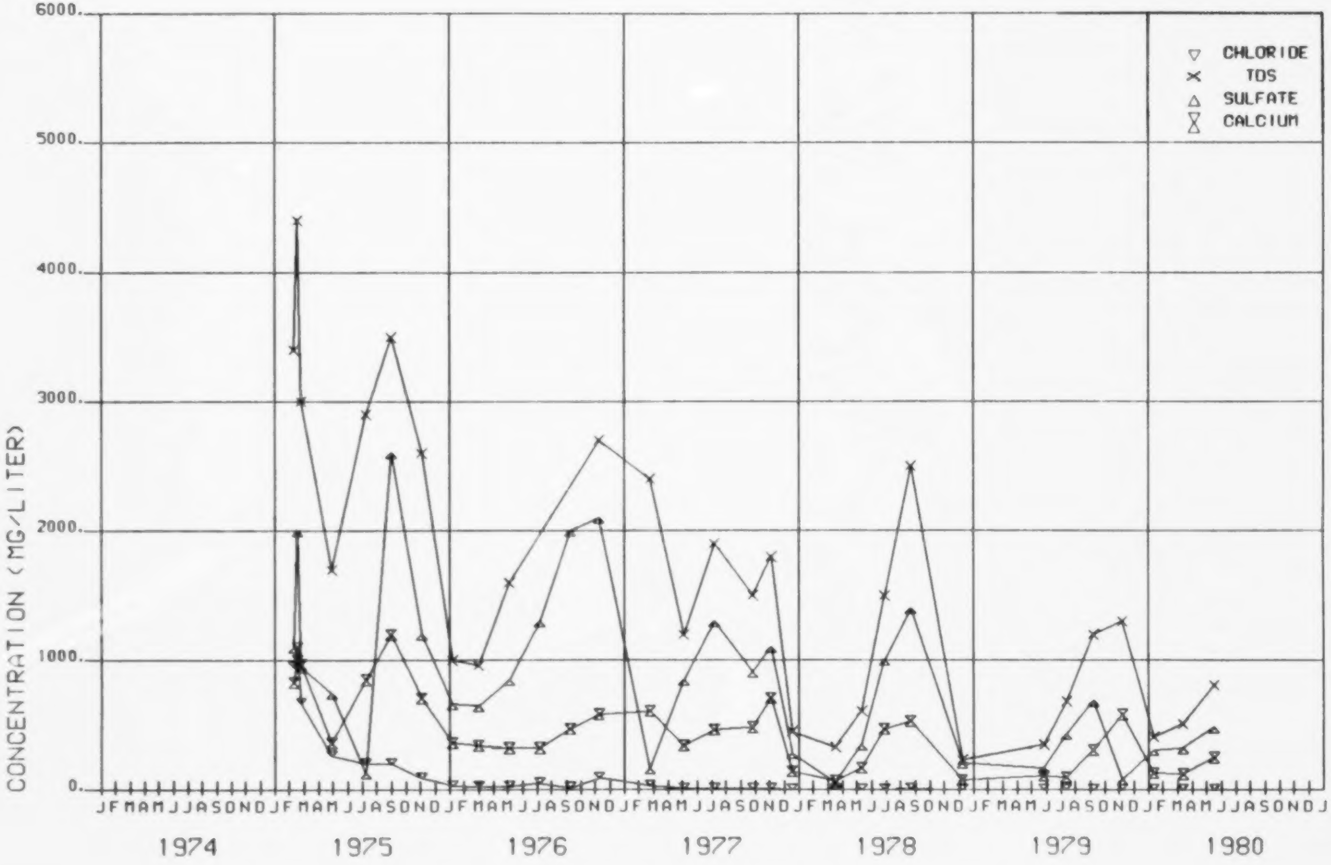


Figure 36. Concentration of TDS and major species in Site D supernate

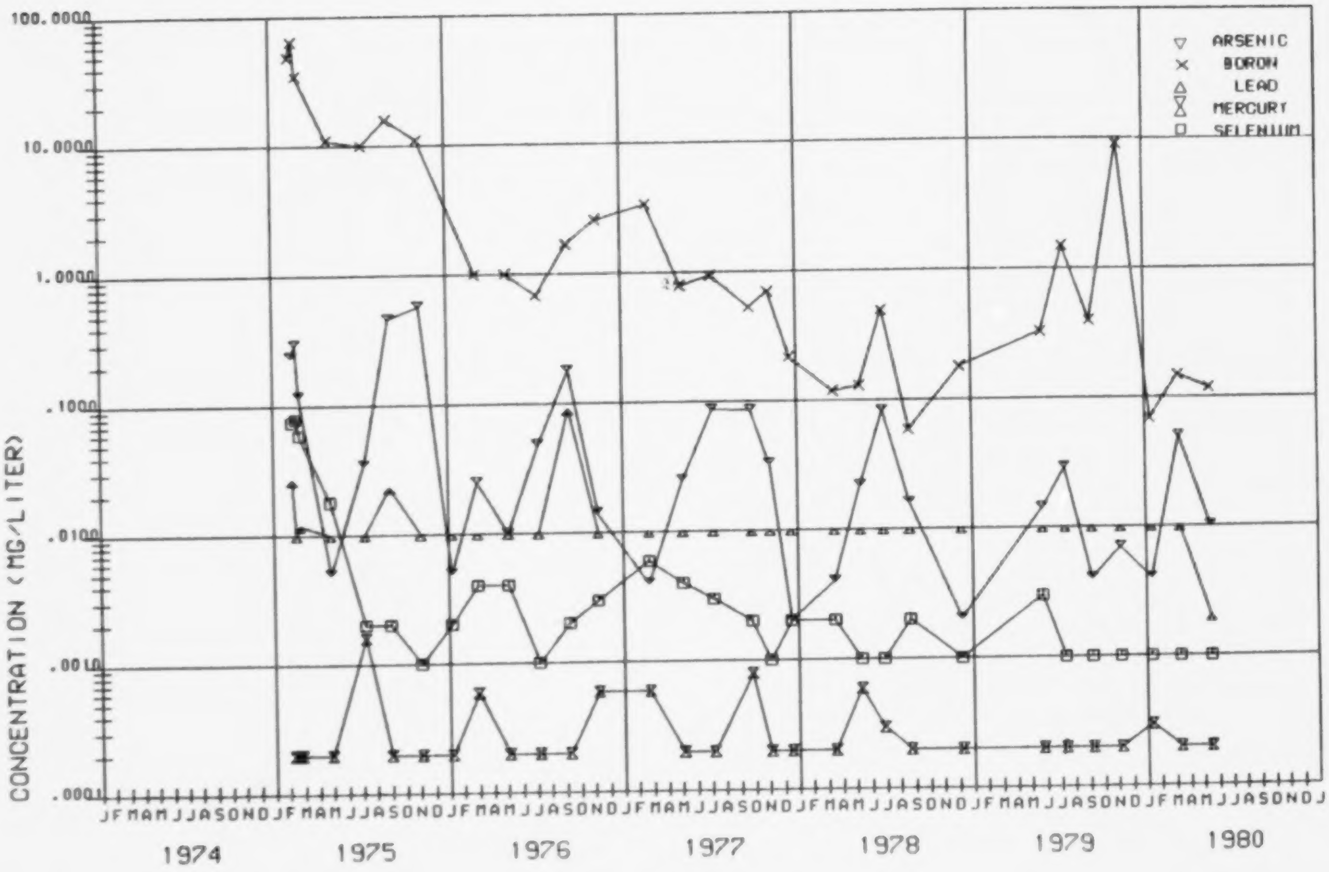


Figure 37. Concentration of minor species in Site D supernate

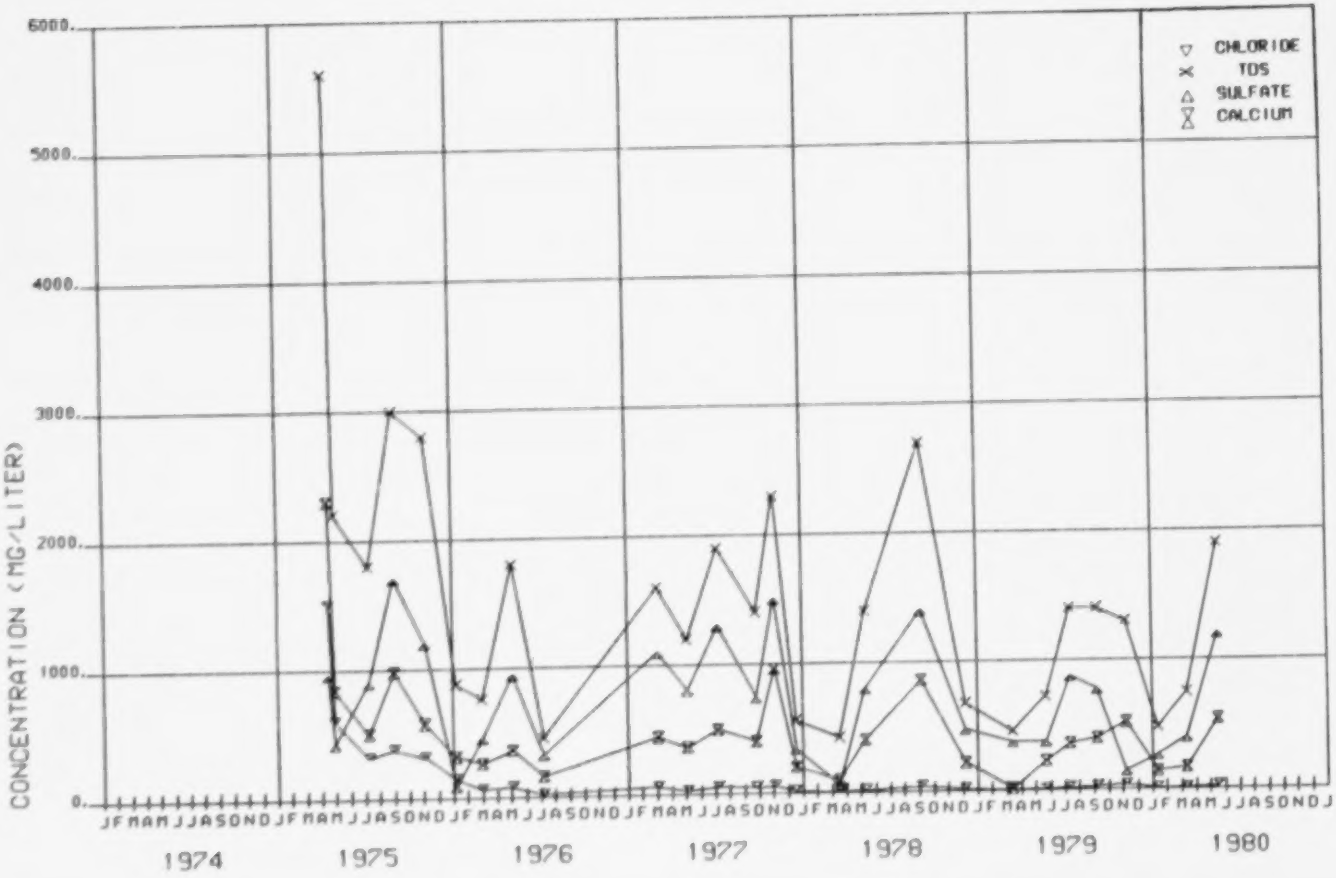


Figure 38. Concentration of TDS and major species in Site B supernate

the repetitive peaks have gradually decreased. Chloride has been virtually depleted since May 1977 (2 years after pond filling), leaving sulfate and calcium as the major dissolved constituents (Figure 39).

The supernate on Site E was sampled and analyzed starting several months after filling in February 1975 and continuing until the site was drained and covered in November 1977. The peak levels reached by the TDS concentration during that time was approximately 2600 mg/l, or about 40% of the TDS concentration in the input liquor. When the site was closed, the TDS concentration had dropped to approximately 1200 mg/l, and the chloride was virtually depleted (Figure 40).

The concentration of minor species from Site C, shown in Figure 41, is typical of the chemically treated sites. Boron concentrations are generally in the range of 1 to 100 mg/l, with arsenic, lead, and selenium varying around 0.01 mg/l. The concentration of mercury was typically less than the above, with a value ranging from 0.0002 to 0.002 mg/l.

5.2.4 Ground Water

A total of 14 ground water wells were placed in and around the waste disposal area to detect possible contamination of the ground water from the disposal site seepage. The location and designation of the ground water wells is given Appendix B, Figure B-2. On the basis of observations of average ground water well depth, the ground water is assumed to move north toward the Ohio River (see Appendix B, Figure B-1), which has an average depth of 15 ft below that of the average disposal well ground water depth. The ground water depth for all of the wells is approximately 321 ft (mean sea level) except for ground water well F2, which has an average depth of 335 ft (mean sea level).

In general, ground water concentration of the major species show a value for TDS of approximately 400 mg/l, with sulfate, calcium, and chloride values of 100 mg/l or less. These values typify the background concentrations of the major species in the ground water. As an example, concentration of the major species for ground water well B2 is plotted in Figure 42.

The ground water analyses of wells upstream and downstream of the underdrained, chemically treated, and gypsum surface sites do not show any discernible effect from seepage from these sites. Occasionally, data were obtained showing ground water TDS concentrations at variance with typical values; however, these concentrations were short-lived and subsequent values were in the typical value range.

In the case of the untreated waste, particularly for Site D, the analyses of the ground water has shown a somewhat higher concentration of chloride and TDS than the ground water associated with the other disposal ponds. The calcium and chloride concentrations remained at a low level (less than 200 mg/l) for most of the monitoring period, while the sulfate fluctuated slightly around 300 mg/l, with an increase to more than 700 mg/l during the

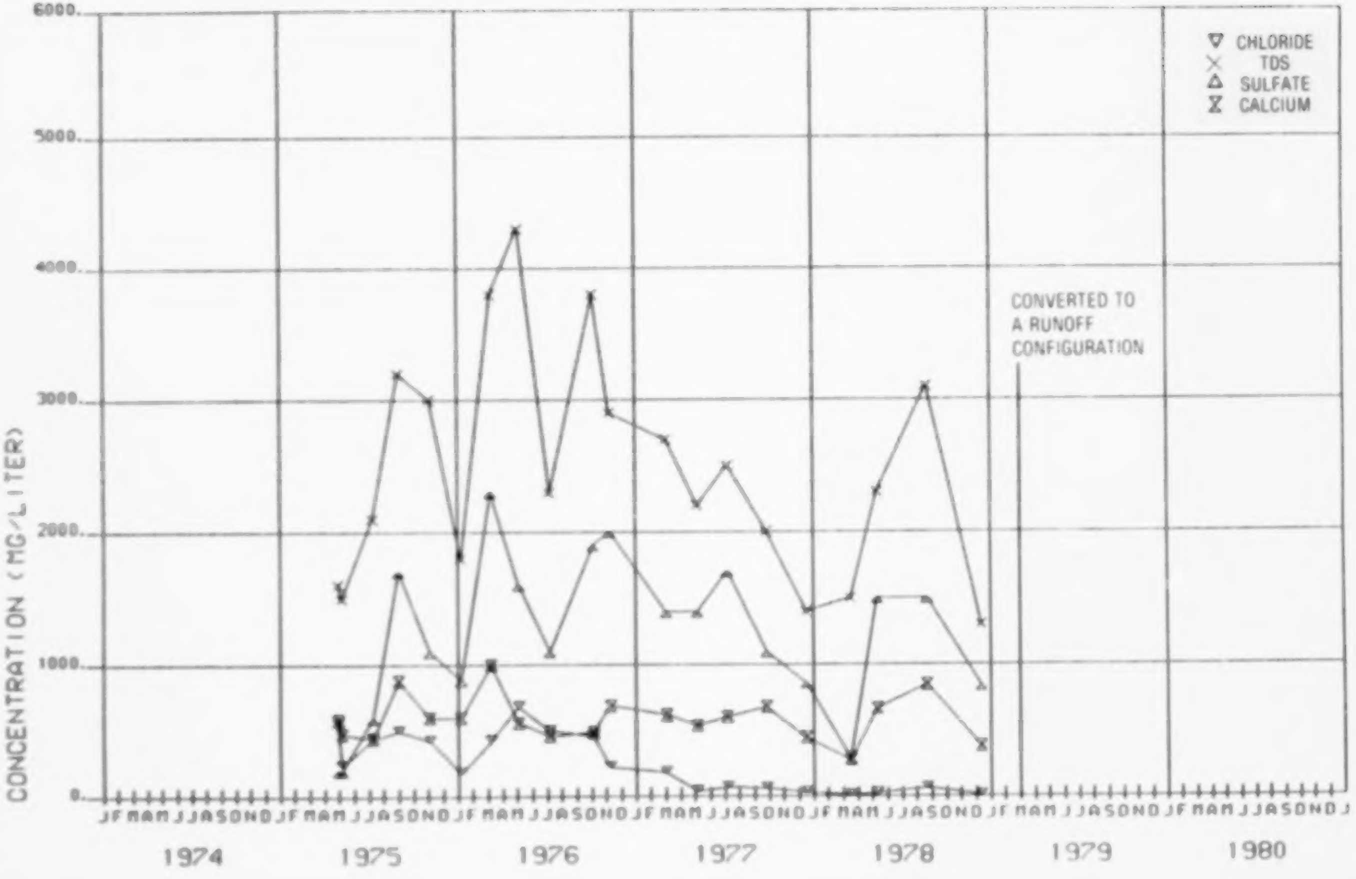


Figure 39. Concentration of TDS and major species in Site C supernate

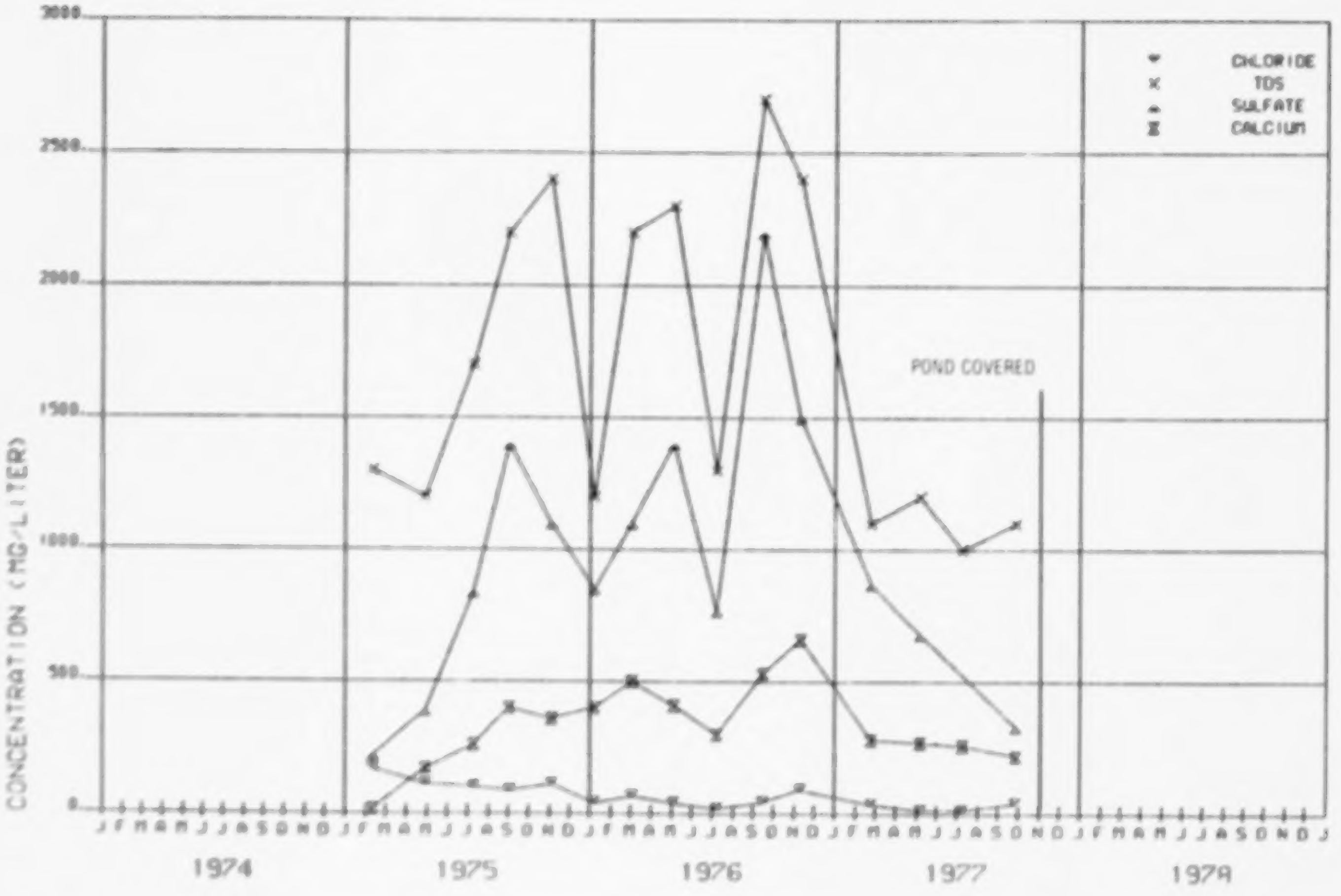


Figure 40. Concentration of TDS and major species in Site E supernate

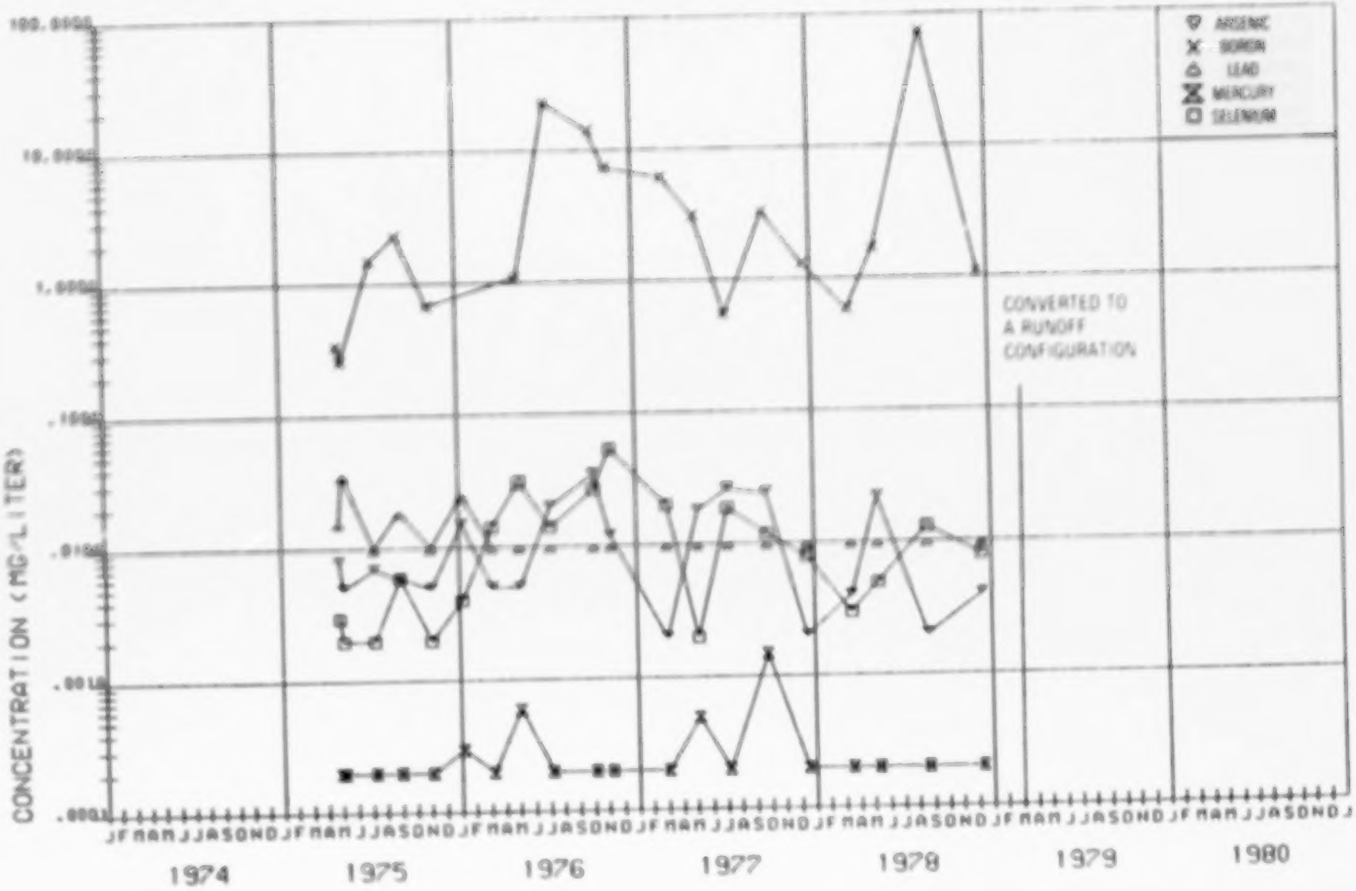


Figure 41. Concentration of minor species in Site C supernate

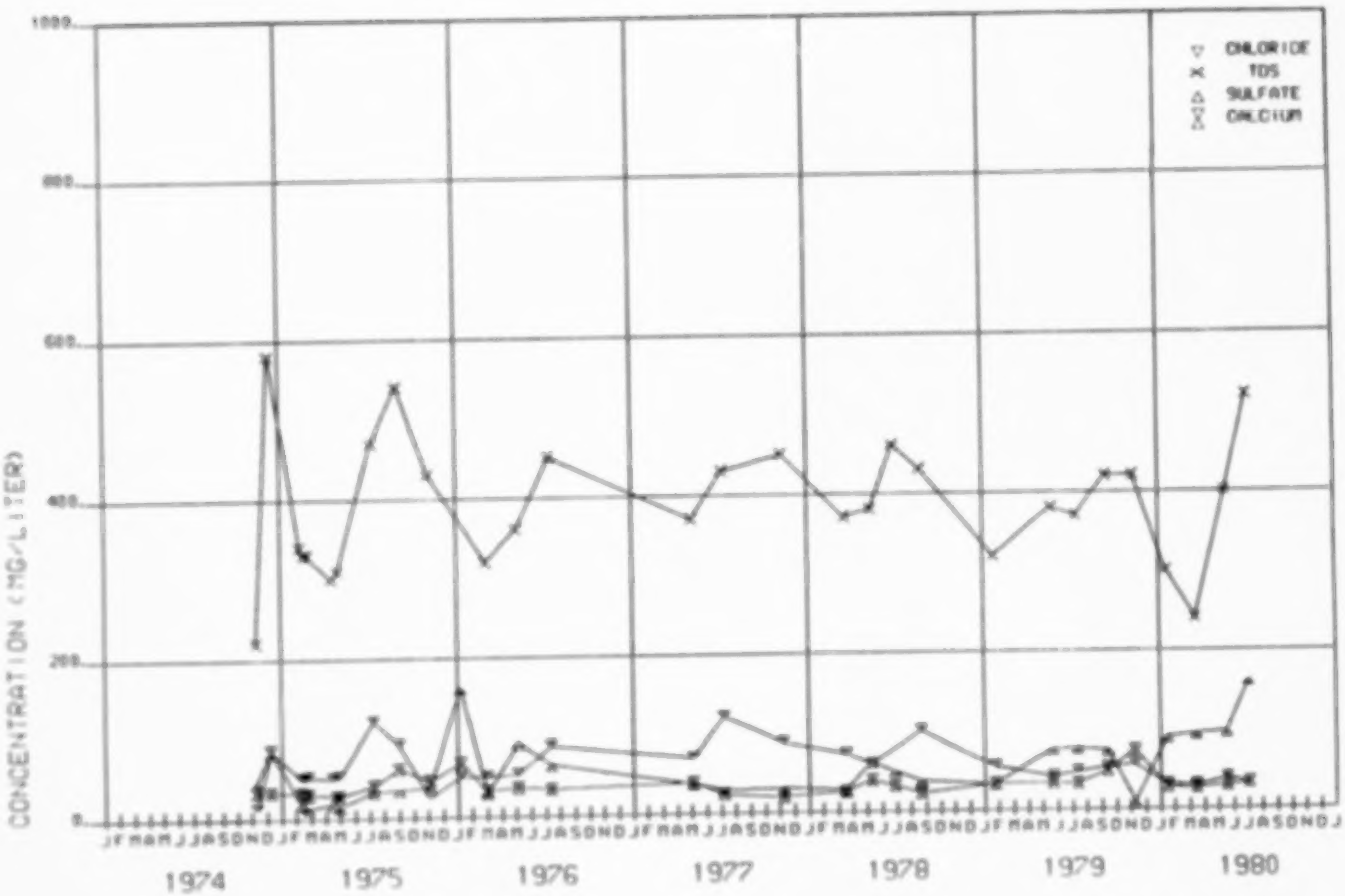


Figure 42. Concentration of TDS and major species in Site B ground water

latter part of 1979 (Figure 43). The TDS concentration also increased during this time. The concentration of the major species for the downstream well, however, do not show this trend. As shown in Figure 44, recent TDS levels are relatively constant. The increase in TDS during mid-1975 and 1976 in the downstream well C2 is evident in other distant ground water wells (e.g., ground water well E1) and is apparently not associated with the untreated pond. Thus, it appears that the increase in TDS and chloride in ground water well D1 is a local phenomenon, possibly due to seepage into the well shaft and not an effect of ground water contamination from the site itself.

The five minor species being analyzed in the ground water wells show no unusual concentrations. For example, the minor species in the ground water well D1 is plotted in Figure 45. Although the concentrations are variable, there do not appear to be any indications of abnormally high concentrations.

5.3 WATER REUSE IN AN UNDERDRAINED DISPOSAL SITE

An analysis of an underdrain system has been completed in which the design and cost of the system and the potential buildup of chloride in an FGD scrubber system that utilizes recirculating water from an underdrained site were evaluated. The underdrain design and the chloride ionic balance are considered in detail in the following paragraphs. The cost of the underdrain system is discussed in Section 6.4.

5.3.1 Underdrain Design

An analysis of an underdrain design was conducted to determine an understanding of the major components necessary to estimate the system costs. The analysis provided an estimation of seepage rate through the untreated waste and subsoil for a system vented to the atmosphere, calculation of drain pipe spacing for horizontal and sloped disposal site bottoms, and an evaluation of five alternative perforated-pipe and sand-layer designs.

The estimation of seepage rates through waste layers in waste disposal sites and into the subsoil utilized a simplified relationship neglecting evaporation, capillary effects, and interference with the natural water table. The analysis assumed a quasi-steady flow through a saturated medium at rates governed by Darcy's law.

Characteristic drain times and seepage rates were estimated for a waste layer thickness in a 6-ft deep model (e.g., Site F) and a full-scale, 50 acre, 30-ft deep, module of the disposal site. Drainage rates are in the vicinity of 1.5×10^{-4} cm/sec. In order to prevent the buildup of rainfall and input liquor within and on top of the waste layer, the design rate of seepage removal at the bottom of the site must exceed the rate at which water is introduced. Based on an average rainfall of 4.3×10^{-6} cm/sec (1 in./wk) and scrubber output on the pond of 4.9×10^{-5} cm/sec (1600 gpm), the seepage is about three times the input rate. Even during heavy rainstorms (say, 8 in./wk), when underdrain is provided, water would not accumulate on top of the

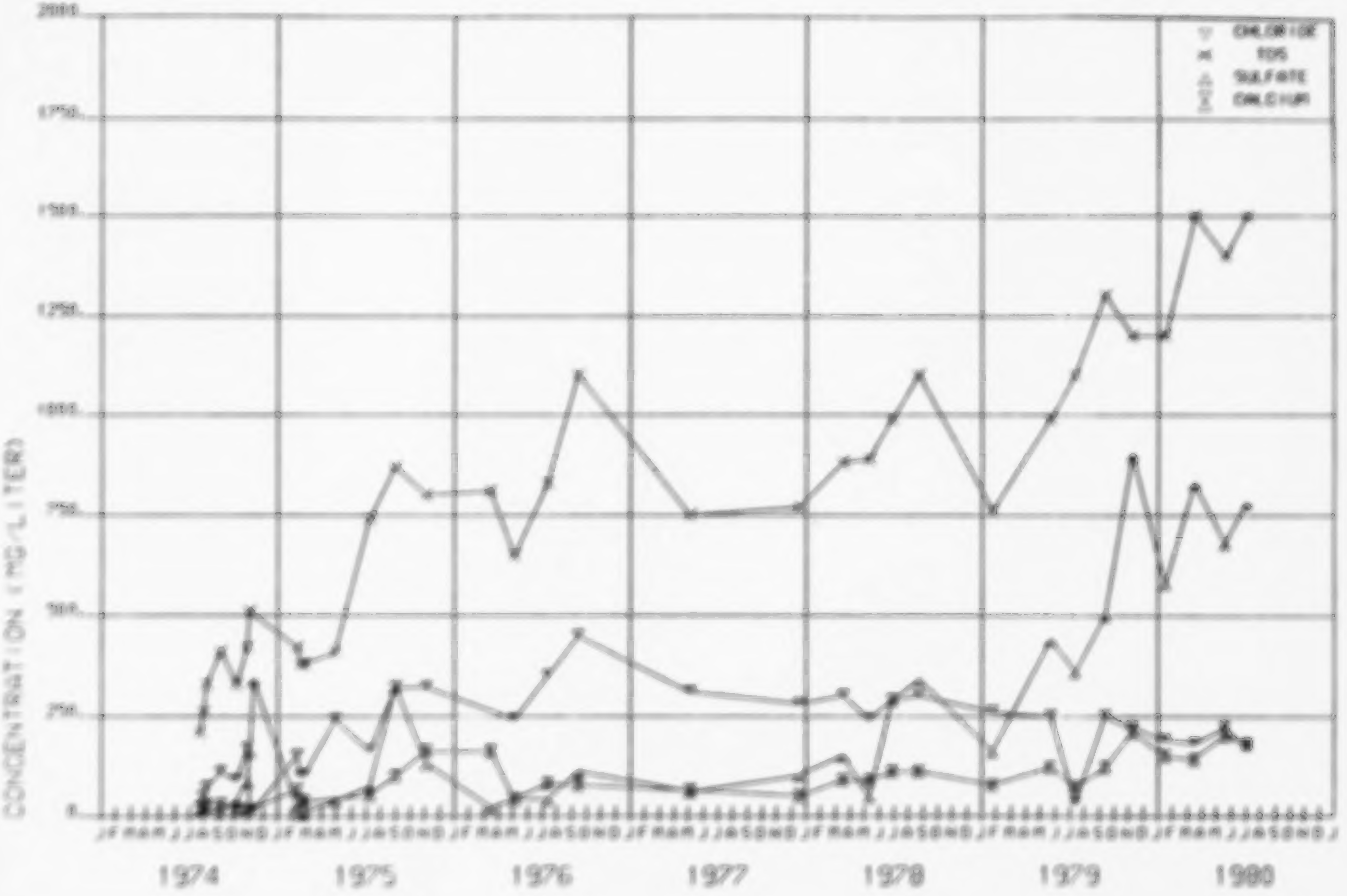


Figure 43. Concentration of TDS and major species in Site D ground water

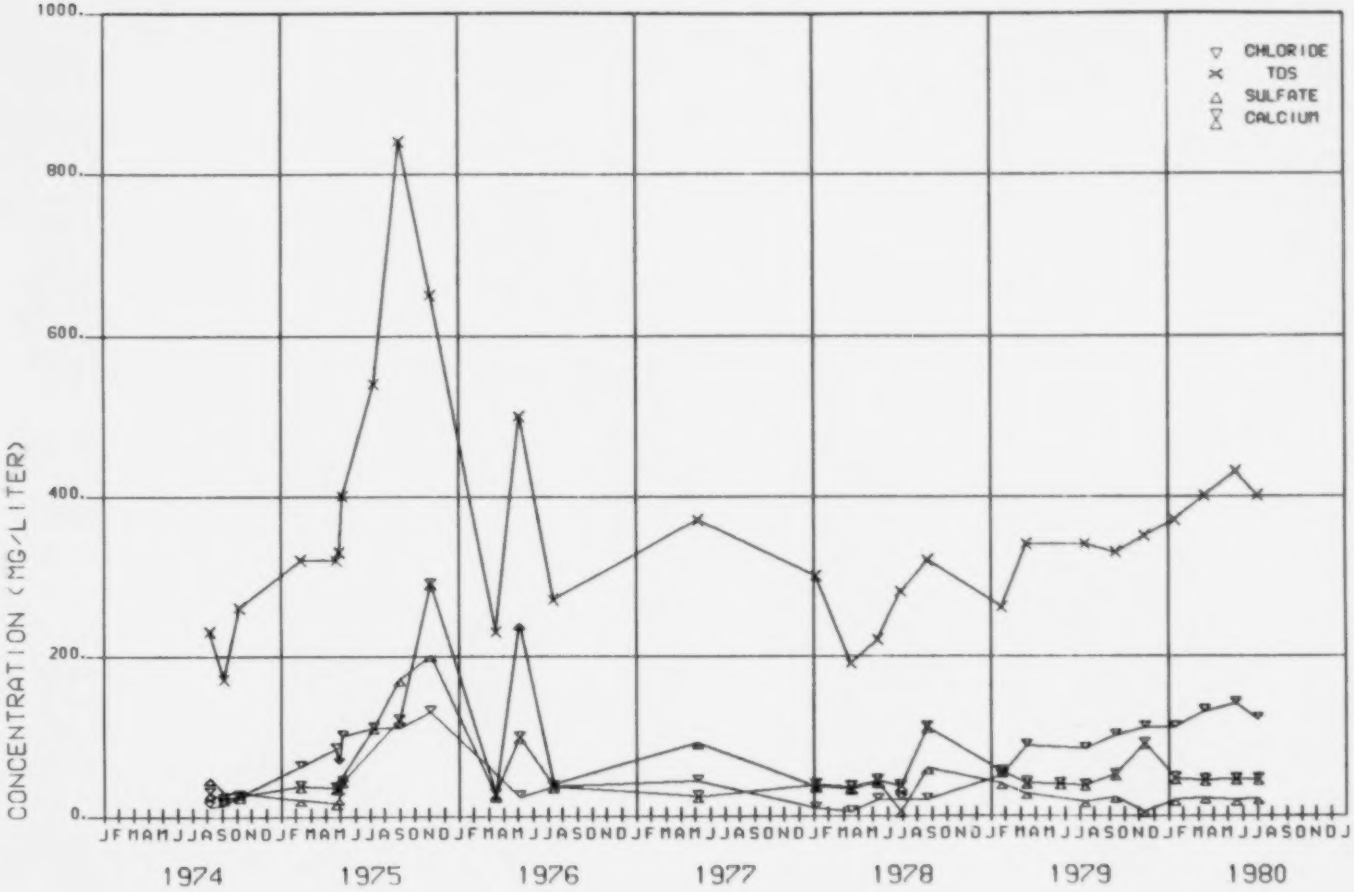


Figure 44. Concentration of TDS and major species in Site C ground water

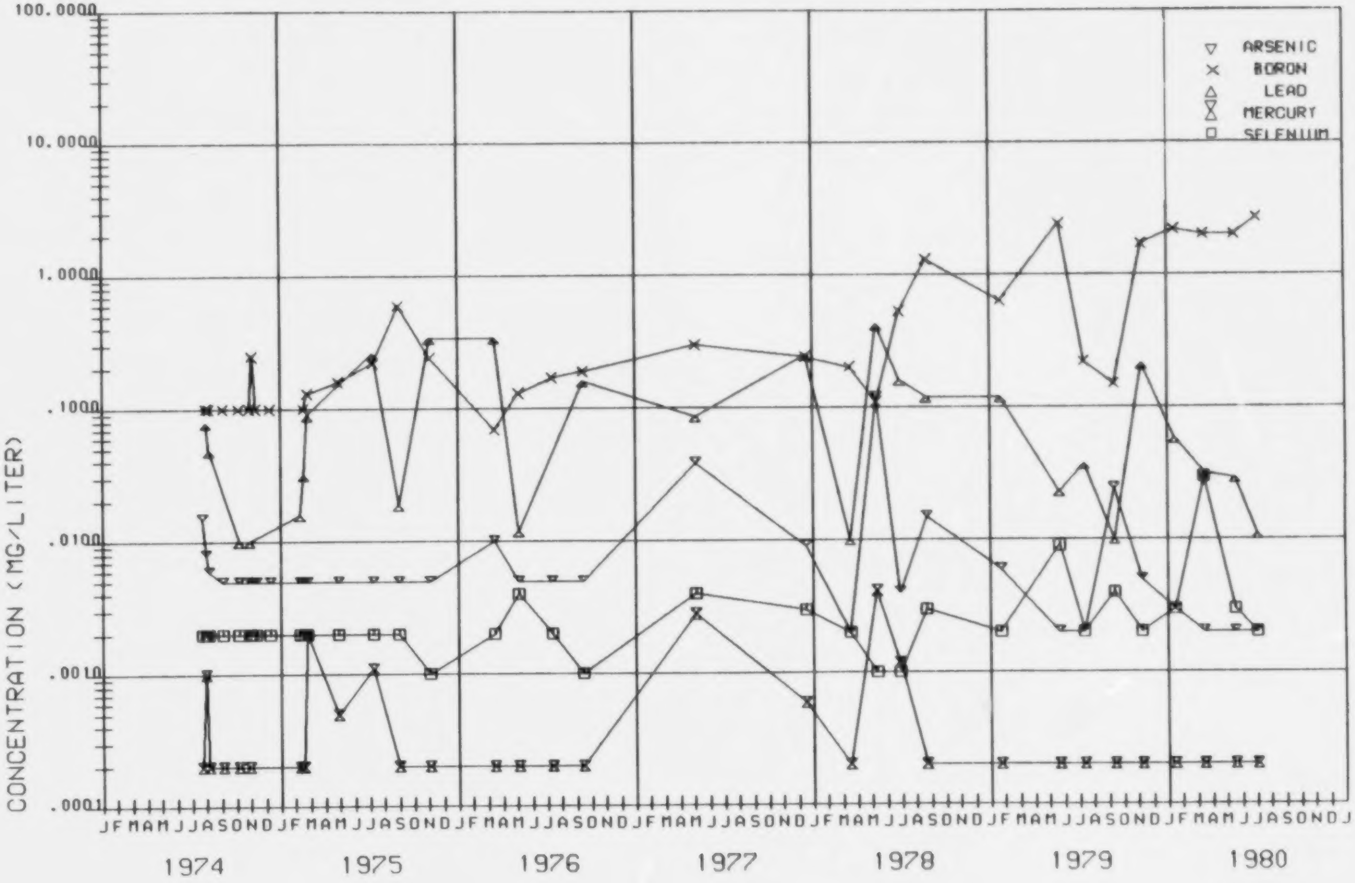


Figure 45. Concentration of minor species in Site D ground water

waste material. If such a condition were to exist whereby the scrubber could not accept the total seepage, water would merely be allowed to accumulate and then drawn down in the future as allowed by scrubber operation.

Seepage into the subsoil was estimated assuming various hydrostatic pressure heads at the waste and subsoil interface and no interference with the natural water table. If, for example, the subsoil coefficient of permeability were 10^{-6} cm/sec, the penetration with underdrainage would be 14 in./yr in the vicinity of the trenches holding the drainage pipes, which may be approximately 10 in. × 10 in. and as much as 100 ft apart or greater; penetration of the soil between the drain trenches would be negligible because the water would be only a film on the base of the site. By comparison, the subsoil seepage from a similar disposal site without underdrains would be about 6 ft/yr from the entire base area of the site. Considering the depth of seepage and the base area contributing to the seepage, the underdrained site would release about 0.4% as much water as the nondrained disposal site. Additionally, the underdrained site would be closed, capped, and reclaimed after about 2 years, thereby preventing future seepage.

The second analysis considered the maximum spacing between drains for several cases. Dupuit/Forchheimer and Boussinesq assumptions (Refs. 8 through 11) were used with Darcy's law to create a seepage model with replenishment, which was used to derive drain spacing relationships with various layer depths to be installed beneath a disposal site. The height of the water-void boundary surface in the sand as a function of the horizontal coordinate was obtained, for both level and slightly inclined beds, by expanding the solutions as a perturbation series in powers of the bed slope. For example, using a 1-ft thick sand layer and following the requirement that the theoretical water level in the drains is zero, the maximum spacing between drains in a horizontal base was found to be 133 ft, which in a base inclined at a 1% slope, the maximum spacing is increased to 240 ft.

The five alternative perforated-pipe and sand-layer designs were used in combination with price lists for materials and labor to select the final cost-minimizing design. A summary of optimum design characteristics (assuming no safety factor) for three sand-layer thicknesses 3.5, 2.0, and 1.0 ft, is given in Table 28. For the last two thicknesses, sand layers with horizontal beds and with beds alternately sloped at 1% toward the field drains were examined as subcases, whereas the 3.5-ft case was examined for the sloped condition only.

Inclining the base at 1% toward the drains reduces the number (and linear feet) of drainpipes required by a factor of about two, because it increases the allowable spacing between drains. It also doubles the discharge that must be carried by the drain, but the pipe diameter needed for the horizontal sand layer designs is also large enough to carry the increased discharge from the sloped layers.

In a comparison of the various designs, the costs of grading the sand-layer bed, trenching, and gravel were also considered. For example, it

TABLE 28. SUMMARY OF OPTIMUM DESIGNS FOR DIFFERENT SAND LAYERS

Item[a]	Design I[b]	Design IIA	Design IIB	Design IIIA	Design IIIB
Sand-Layer Thickness, ft	3.5	2.0	2.0	1.0	1.0
Bed Slope, %	1.0	0	1.0	0	1.0
Number of Drains	--	4	2	9	5
Drain Spacing, ft	--	300	600	133	240
Drain Discharge, ft3/sec	--	0.059	0.118	0.026	0.047
Diameter of Drain d, in.	--	6	6	4	4
Slope of Drain, %	--	0.5	0.5	0.5	0.5
Total Length Required, ft	--	4800	2400	10,800	6000
Header Discharge, ft^3/sec	--	0.236	0.236	0.236	0.236
Diameter of Header, in.	8	8	8	8	8
Slope of Header, %	0.5	0.5	0.5	0.5	0.5
Total Length of Header, ft	2400	2100	1800	2300	2160
Volume of Sand, ft^3	5.0×10^6	2.9×10^6	2.9×10^6	1.4×10^6	1.4×10^6

[a] Assumed values:
$q = 10^{-5}$ cm/sec (replenishment rate)
$k = 0.1$ cm/sec (sand conductivity)
$M = 0.02$ $sec/ft^{1/3}$ (friction factor)
$t = 4$ in. (thickness allowance for waste infiltation into sand layer)

[b] In Case I, drain pipe and heater are the same.

might appear that, because Design IIb in Table 28 requires only 2400 ft of 6-in. pipe while Design IIa requires 4800 ft, the former is the more economical design. However, Design IIb calls for accurately grading the sand-layer bed to alternating slopes every 300 ft, while IIa requires only that the bed be graded horizontally. The incremental cost of specialized grading may offset the cost of an additional 2400 ft of perforated pipe.

5.3.2 Ionic Balance

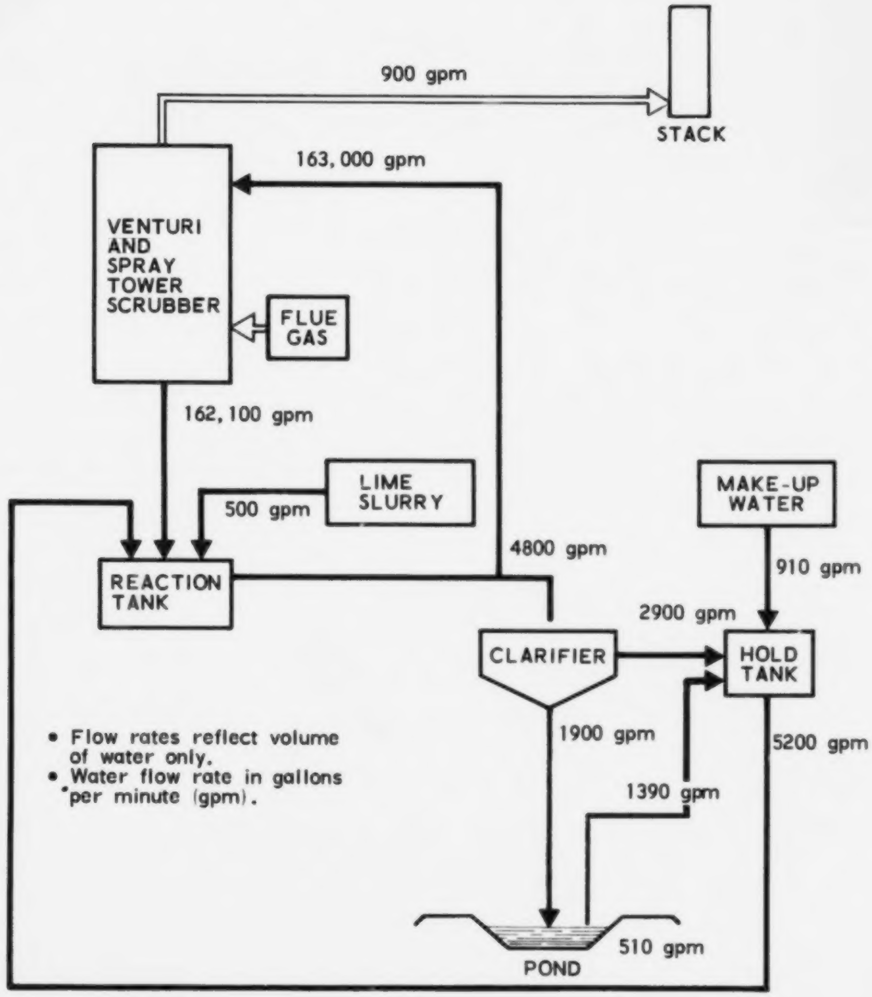
The theoretical scrubber system chosen for the chloride balance calculation is based on the TVA 10-MWe venturi spray tower scrubber using lime absorbent scaled up to a 1000-MWe plant, which is shown in Figure 46 (Ref. 12). This system, without underdrainage, is illustrative of a closed-loop water system that requires a total of 1410-gpm fresh makeup water to replace 900 gpm lost up the stack and 510 gpm lost by occlusion in the ponded waste containing 45% solids. The flow rate into the disposal site is 1900 gpm, from which 1390 gpm of supernate is returned to the scrubber loop; this return results from settling of the clarifier underflow from 30% solids to 45% solids. The flow in and out of the site represents roughly 1% of the total water flow through the scrubber system.

The evaluation of the ionic balance is based on this scrubber system. This system was modified to include an underdrain system and, later, to include the oxidation of the wastes, which increase the solids contents and the amount of water recirculated to the scrubber system. The sensitivity of the chloride balance to the initial parameters was considered as well as the effects on this balance from multiple site disposal.

The major source of chloride in the scrubber system is from chlorine present in the coal, primarily in the form of inorganic chlorides such as sodium, potassium, and calcium chloride. The range of chloride in U.S. coals can vary from a negligible content to one as high as 0.56%. A typical value would be about 0.15%, which was found to be the average present in 82 coals from the Illinois Basin (Ref. 13).

Base System

The base system shown in Figure 47 is a scrubber system using lime absorbent with a 50-acre disposal site module without underdrainage. A 1000-MW utility steam plant would require a total of 16 modules (780 acres) to contain the waste produced in a 30-year plant lifetime. The amount of rainfall and evaporation at the disposal site can be estimated from typical meteorological conditions. The estimates used here are from conditions found at the Shawnee Steam Plant near Paducah, Kentucky, and are described in greater detail in Appendix F.1. The total amount of water falling onto a 50-acre area (at a rate of about 48 in./yr) is 65×10^6 gal/yr or an average of 124 gpm. Using average monthly values of air temperature, relative humidity, and other meteorological conditions, evaporation from a ponded surface is estimated at 112 gpm for a 50-acre site (Appendix F.2). Although the rainfall and peak evaporation do not occur simultaneously, they are considered as concurrent

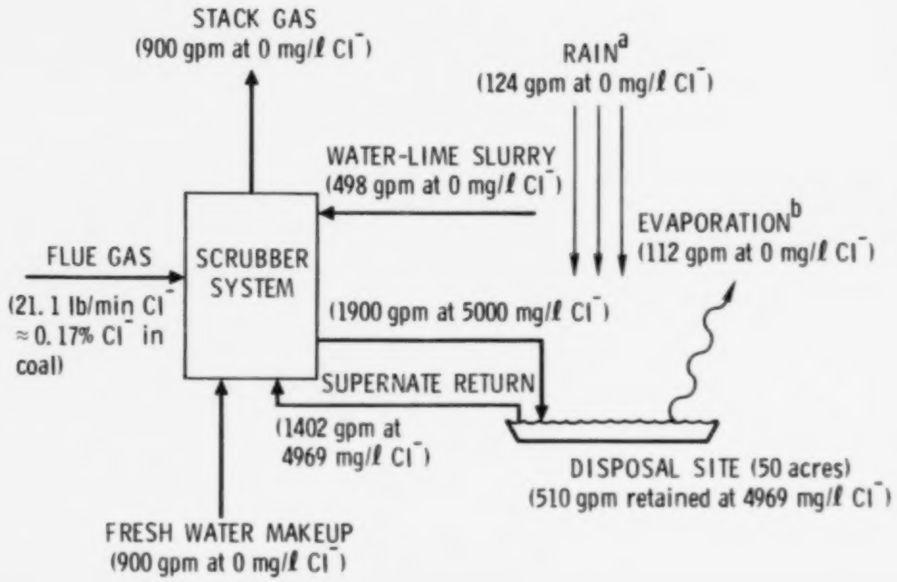

STACK
900 gpm
163,000 gpm
VENTURI AND SPRAY TOWER SCRUBBER
FLUE GAS
162,100 gpm
LIME SLURRY
500 gpm
REACTION TANK
4800 gpm
MAKE-UP WATER
910 gpm
2900 gpm
CLARIFIER
HOLD TANK
1900 gpm
5200 gpm
1390 gpm
POND
510 gpm

- Flow rates reflect volume of water only.
- Water flow rate in gallons per minute (gpm).

EXTRAPOLATED OPERATING CONDITIONS

- LIQUID-TO-GAS RATIO: 54.0 gal/1000 cu ft
- SCRUBBER EFFLUENT SOLIDS: 8%
- CLARIFIER UNDERFLOW SOLIDS: 30%
- SOLIDS IN SETTLED WASTE: 45%
- COAL: 3.4% SULFUR
- SO_2 REMOVAL EFFICIENCY: 90%
- 1000-MW EQUIVALENT OPERATION

Figure 46. Water balance for a 1000-MW venturi-spray tower FGD scrubber


STACK GAS
(900 gpm at 0 mg/ℓ Cl⁻)
RAIN[a]
(124 gpm at 0 mg/ℓ Cl⁻)
WATER-LIME SLURRY
(498 gpm at 0 mg/ℓ Cl⁻)
EVAPORATION[b]
(112 gpm at 0 mg/ℓ Cl⁻)
FLUE GAS
SCRUBBER SYSTEM
(21.1 lb/min Cl⁻ ≈ 0.17% Cl⁻ in coal)
(1900 gpm at 5000 mg/ℓ Cl⁻)
SUPERNATE RETURN
(1402 gpm at 4969 mg/ℓ Cl⁻)
DISPOSAL SITE (50 acres)
(510 gpm retained at 4969 mg/ℓ Cl⁻)
FRESH WATER MAKEUP
(900 gpm at 0 mg/ℓ Cl⁻)

CHLORIDE BALANCE

FLUE GAS + SUPERNATE RETURN = SCRUBBER OUTPUT

$$21.1\ \text{lb/min} + 1402\ \text{gpm} \times 8.34\ \text{lb/gal} \times \left([\text{Cl}^-] \times \frac{1900\ \text{gpm}}{1912\ \text{gpm}}\right)^{c} = 1900\ \text{gpm} \times 8.34\ \text{lb/gal} \times [\text{Cl}^-]$$

Where

$[\text{Cl}^-] = 0.005$ OR 5000 mg/ℓ

---

[a] Based on 48 in./yr

[b] Based on evaporation from a shallow lake

[c] Chloride return with rain/evaporation dilution factor

Figure 47. Water balance for a pond disposal system, settled to 45% solids content

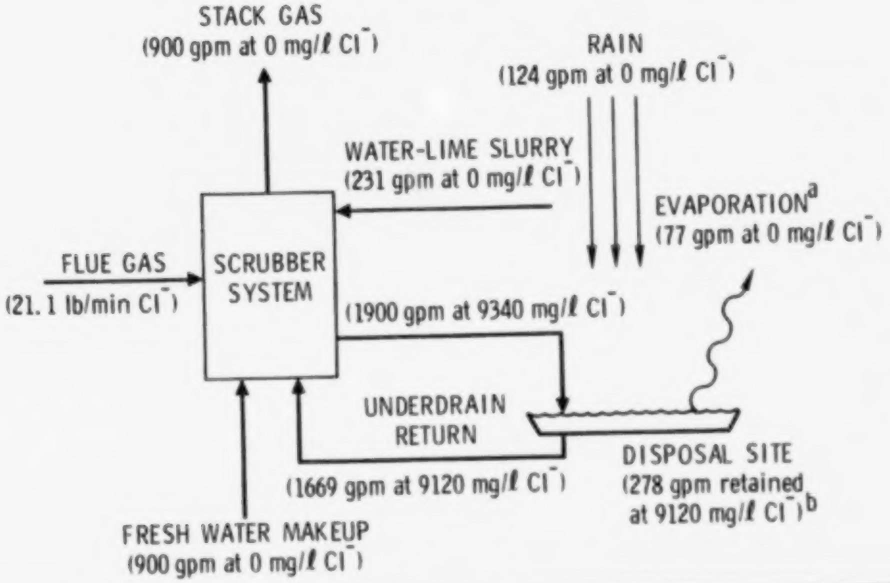
average values for purposes of this analysis. A 50-acre operating site, with a depth of 30 ft was chosen as a reasonable size in terms of operating efficiency and physical accessibility. This site has the water waste capacity, operating initially at 7000 hr/yr, for nearly 2 years for the nondrained pond and greater than 3 years for the gypsum underdrained case (Appendix F.3), which is discussed later. Surge capacity to handle conditions such as heavy rainfall can be provided by limiting the underflow return or by using an adjacent disposal site not yet used or filled.

Data from the initial Shawnee evaluation study (Ref. 1) indicate that for the base system operation, a steady-state condition of 5000 mg/l Cl^- concentration may be expected in the scrubber. A slightly reduced Cl^- concentration should be reached in the returned supernate as a result of the dilution of the supernate by rainwater. The chloride input from the flue gas necessary to obtain the observed steady-state Cl^- concentration in the scrubber loop was estimated to be 21.1 lb/min Cl^- or approximately 0.17% chloride in the coal (Appendix F.4), which is consistent with the range of chloride concentration in coals noted earlier. In Figure 47, the chloride balance is demonstrated by setting the input chloride, from the flue gas stream and the returning supernate, equal to the chloride content of the scrubber output. It is assumed that all the chloride is dissolved in the water, including the water retained in the waste. In an actual case, any chloride that may be retained with the solid waste material would reduce the chloride circulating in the scrubber loop and thus reduce the steady-state chloride concentration.

Underdrained System, Lime/Limestone Absorbent

The effect of an underdrained system on the scrubber loop water and chloride balance is shown in Figure 48. This system is based on waste high in calcium sulfite, derived from lime absorbent, and settled to 60% solids. Sixty percent is characteristic of the average solids content value obtained in cores from underdrained Sites G (lime) and F (limestone). Whereas the amount of rainfall on a 50-acre site was the same as the estimate in the base system without underdrainage, the amount of evaporation will differ. Evaporation from an underdrained site is based on estimated evapotranspiration rates from a soil mass and local climatological data and was found to be equivalent to 77 gpm (Appendix F.5). A survey of the literature did not reveal a method of estimating evaporation completely compatible with an underdrain system because the waste has neither standing water nor is it a dry soil mass. The sensitivity of the chloride concentration to the evaporation estimate is discussed later in this section.

With the waste settling to 60% solids, a total of 278 gpm of water is retained in the disposal site (Appendix F.3) with a corresponding concentration of Cl^- equal to 9120 mg/l. As in the base system, dilution due to the rainfall yields a lower Cl^- concentration in the return water than the scrubber output. The underdrain return has a total of 1669 gpm at 9120 mg/l Cl^-, and the scrubber output has a flow rate of 1900 gpm at 9340 mg/l Cl^- for the steady-state condition (Figure 48).


STACK GAS
(900 gpm at 0 mg/ℓ Cl⁻)
RAIN
(124 gpm at 0 mg/ℓ Cl⁻)
WATER-LIME SLURRY
(231 gpm at 0 mg/ℓ Cl⁻)
EVAPORATION[a]
(77 gpm at 0 mg/ℓ Cl⁻)
FLUE GAS
(21.1 lb/min Cl⁻)
SCRUBBER SYSTEM
(1900 gpm at 9340 mg/ℓ Cl⁻)
UNDERDRAIN RETURN
DISPOSAL SITE
(1669 gpm at 9120 mg/ℓ Cl⁻)
(278 gpm retained at 9120 mg/ℓ Cl⁻)[b]
FRESH WATER MAKEUP
(900 gpm at 0 mg/ℓ Cl⁻)

CHLORIDE BALANCE

$$\underline{\text{FLUE GAS}} + \underline{\text{UNDERDRAIN RETURN}} = \underline{\text{SCRUBBER OUTPUT}}$$

$$21.1 \text{ lb/min} + 1669 \text{ gpm} \times 8.34 \text{ lb/gal} \times [Cl^-] \times \frac{1900 \text{ gpm}}{1947 \text{ gpm}} = 1900 \text{ gpm} \times 8.34 \text{ lb/gal} \times [Cl^-]$$

Where

$[Cl^-] = 0.00934$ OR 9340 mg/ℓ

---

[a] Based on water loss from evapotranspiration estimates

[b] Change in gpm due to additional setting of solids and reduction in evaporation (see text)

Figure 48. Water balance for an underdrained disposal system, settled to 60% solids content

Underdrained System, Gypsum Waste

A case similar to the lime/limestone underdrain site has been calculated for a gypsum waste. Figure 49 describes the gypsum case, which for this analysis varies only by the degree of waste settling. Since the chloride concentration of the scrubber loop increases with increased solids content, the gypsum case (with a high solids content) would represent a worst case situation. Settling to a solids content of 80% appears to be reasonable for a slurried gypsum material, based on recent core samples and on the detailed underdrained filling data presented in Appendix F.6. The amount of water retained in the gypsum that settles to 80% equals 104 gpm (Appendix F.3). As before, the chloride content of the scrubber output and the underdrain return differs as a result of dilution by the unevaporated rainwater. The scrubber output consists of 1900 gpm with a Cl^- concentration of 25,000 mg/l, and the underdrain return is 1843 gpm at 24,400 mg/l Cl^-. The amount of chloride retained in a 50-acre pond is equivalent to 104 gpm at 24,400 mg/l Cl^-.

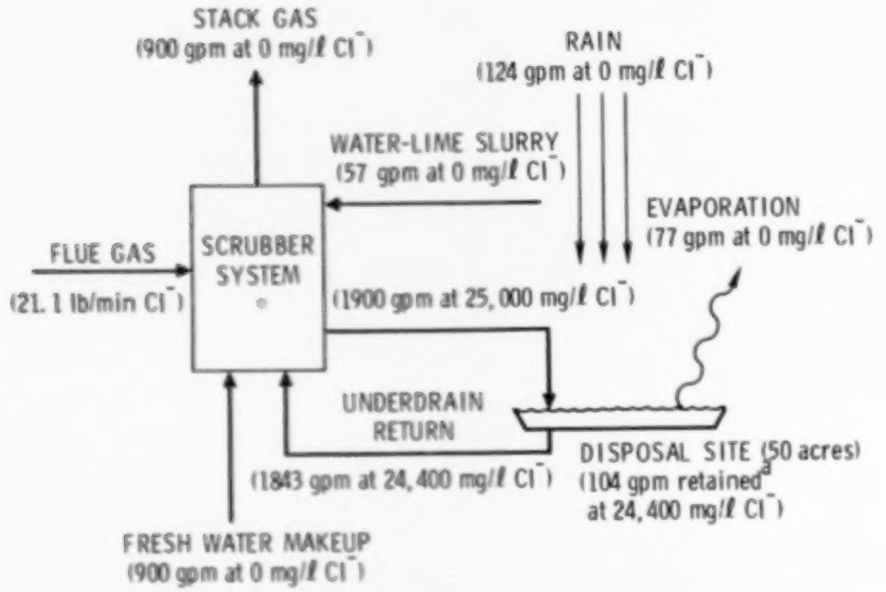
Sensitivity of the Chloride Balance in an Underdrain System

The steady-state chloride balance can yield a variety of Cl^- concentrations, depending on the initial conditions. This variability of the steady-state chloride concentration when each parameter is varied individually is shown in Figure 50. The parameters considered included site size, chloride concentration in the coal, moisture retained in the disposal site, and evaporation from the disposal site. The maximum and minimum limits were chosen to represent realistic ranges for each value so that the relative impact of each variable can be compared. In Figure 50 the scale is set so that the steady-state chloride concentration increase is to the left. In addition, it may be noted that as disposal site size is varied, the amount of rainfall collected and the evaporation vary proportionately to the size.

From Figure 50 it is apparent that the solids retained in the waste and the chloride content of the coal have the most significant effect on the steady-state chloride concentration in the scrubber loop. The disposal site size and amount of evaporation show only a minor effect on the steady-state chloride balance, as would a change in the rainfall rate (not depicted).

Multiple Site Disposal

An important consideration in evaluating the underdrained disposal method is the effect on the chloride balance after one disposal site module is filled and a new site is opened. A significant amount of water is retained at the disposal site, and the chloride dissolved in that water is also retained. The only chloride that is transferred from one site to a another is that which is dissolved in water draining from the site after retirement (which consists of covering with clay or soil material). The amount of water that drains may be affected by (1) free drainage of occluded water, (2) water squeezed out by site closing activities, or (3) natural settling of the waste under its own weight. At present, it is assumed that all the water that seeps into the underdrainage system is transferred to the next disposal site. However, as


STACK GAS
(900 gpm at 0 mg/ℓ Cl⁻)
RAIN
(124 gpm at 0 mg/ℓ Cl⁻)
WATER-LIME SLURRY
(57 gpm at 0 mg/ℓ Cl⁻)
EVAPORATION
(77 gpm at 0 mg/ℓ Cl⁻)
FLUE GAS
(21.1 lb/min Cl⁻)
SCRUBBER SYSTEM
(1900 gpm at 25,000 mg/ℓ Cl⁻)
UNDERDRAIN RETURN
(1843 gpm at 24,400 mg/ℓ Cl⁻)
DISPOSAL SITE (50 acres)
(104 gpm retained^a at 24,400 mg/ℓ Cl⁻)
FRESH WATER MAKEUP
(900 gpm at 0 mg/ℓ Cl⁻)

CHLORIDE BALANCE

FLUE GAS + UNDERDRAIN RETURN = SCRUBBER OUTPUT

$$21.1\ \text{lb/min} + 1800\ \text{gpm} \times 8.34\ \text{lb/gal} \times [\text{Cl}^-] \times \frac{1900\ \text{gpm}}{1947\ \text{gpm}} = 1900\ \text{gpm} \times 8.34\ \text{lb/gal} \times [\text{Cl}^-]$$

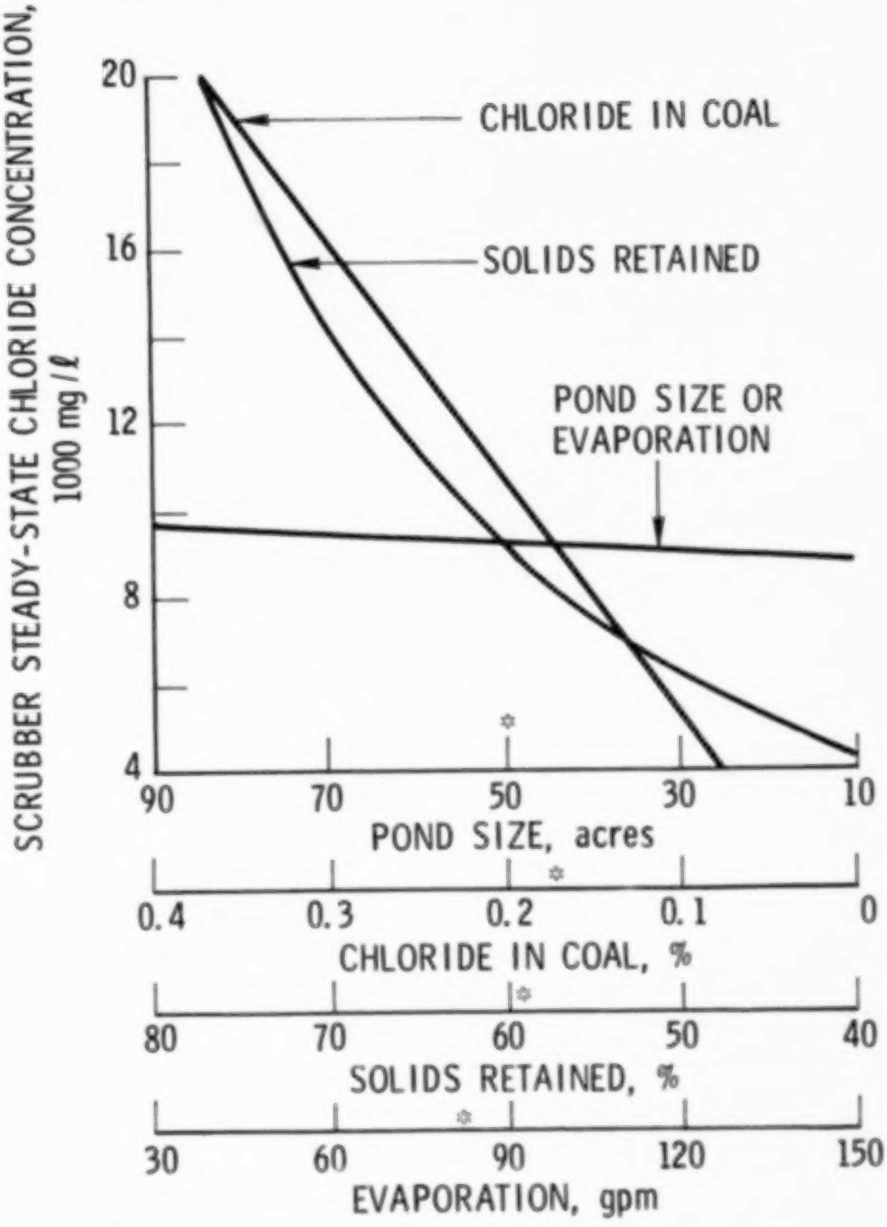
Where

$[\text{Cl}^-] = 0.0250$ OR 25,000 mg/ℓ

---

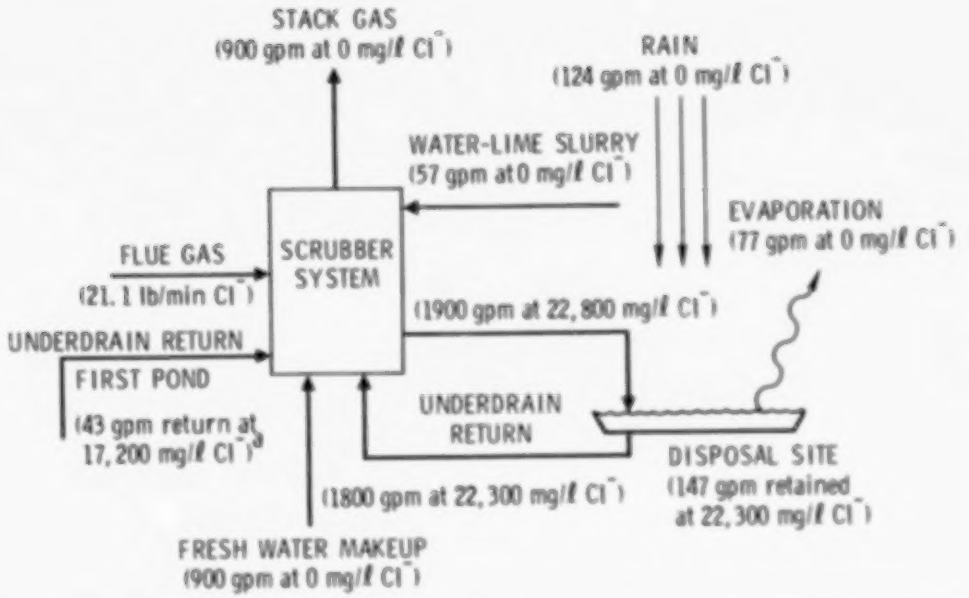
[a] Change in gpm due to additional settling (see text)

Figure 49. Water balance for an underdrained disposal system, gypsum settled to 80% solid content



*As one parameter is varied, all others remain fixed at points indicated by asterisk

Figure 50. Scrubber steady-state chloride balance sensitivity


STACK GAS
(900 gpm at 0 mg/ℓ Cl⁻)
RAIN
(124 gpm at 0 mg/ℓ Cl⁻)
WATER-LIME SLURRY
(57 gpm at 0 mg/ℓ Cl⁻)
EVAPORATION
(77 gpm at 0 mg/ℓ Cl⁻)
FLUE GAS
(21.1 lb/min Cl⁻)
SCRUBBER SYSTEM
(1900 gpm at 22,800 mg/ℓ Cl⁻)
UNDERDRAIN RETURN
FIRST POND
(43 gpm return at 17,200 mg/ℓ Cl⁻)a
UNDERDRAIN RETURN
DISPOSAL SITE
(147 gpm retained at 22,300 mg/ℓ Cl⁻)
(1800 gpm at 22,300 mg/ℓ Cl⁻)
FRESH WATER MAKEUP
(900 gpm at 0 mg/ℓ Cl⁻)

CHLORIDE BALANCE

FLUE GAS AND POND RETURN + UNDERDRAIN RETURN = SCRUBBER OUTPUT

$$27.3 \text{ lb/min} + 6.16 \text{ lb/min} + 1800 \text{ gpm} \times 8.34 \text{ lb/gal} \times [Cl^-] \times \frac{1900}{1947} = 1900 \text{ gpm} \times 8.34 \text{ lb/gal} \times [Cl^-]$$

Where

$[Cl^-] = 0.0223$ OR 23,300 mg/ℓ Cl^-

---

[a] Chloride returned: 43 gpm at 17,200 mg/ℓ Cl^- or 6.16 lb/min Cl^-

Figure 51. Water balance for the second underdrained system, gypsum settling from 74% to 80% solids contents after filling is completed

discussed in subsequent sections, this may be undesirable and can be avoided when necessary.

Free draining of occluded water under its own weight should not be significant since the filling of the disposal site is carried out open to the atmosphere and when the site filling is completed, the hydraulic head is lost and drainage would cease. It is also likely that site covering activities would not induce appreciable drainage since the weight of a soil covering and construction equipment is distributed such that very little compression is felt at a depth greater than 15 ft (Appendix F.7). The third type of draining, i.e., natural settling under its own weight, however, may be important. During the filling of underdrained Site H (gypsum clarifier underflow), detailed records were kept of the quantities of input waste and output of underdrained water. Calculations show (Appendix F.6) that an average of 74% solids was maintained during filling with an increase in solids content to approximately 80% four days after filling. An important difference between this and an operational site is that Site H was small enough to be filled and drained homogeneously. An operational site (50 acres) will have portions drained and settled prior to the closing of the site. With this information, however, an estimate of the effect of changing sites can be made. The gypsum underdrained case was initially chosen for modeling since a higher percent of solids leads to a higher steady-state Cl^- concentration (Figure 50).

The drainage water from a previously filled site will effectively increase the chloride input to the scrubber loop much the same as an increase in the chloride concentration of the coal. Assuming the entire operational disposal site settles from 74% to 80% solids, within one life cycle of the modular disposal site (i.e., 3.5 years), the average additional input of chloride would be equivalent to 43-gpm water taken at the previous site's chloride content of 17,200 mg/l. A solids content of 74% would yield a return chloride concentration of 17,200 mg/l Cl^-, with a volume of 147 gpm returned to the scrubber. The scrubber return volume from settling would be the difference between 147 gpm and that shown in Figure 50 for 80% solids, or 104 gpm, which equals 43 gpm. This condition is represented in Figure 51. The second underdrained site will reach a new steady-state chloride concentration of 22,300 mg/l. This concentration represents an increase in chloride of nearly 30%. However, when this transfer process is repeated from site to site, the net increase in steady-state chloride concentration declines until, after roughly seven transfers, an overall "steady-state" chloride concentration is reached at 24,400 mg/l. This is demonstrated in Table 29. As a comparison, Cl^- buildup from disposal site transfers were calculated for a less severe case, namely, lime/limestone, where solids content are near 60%. Assuming the solids increase from 55% to 60% after filling, an overall steady-state chloride concentration is reached at 9120 mg/l after seven transfers (Table 30).

From the previous discussions, it can be seen that a particular overall steady-state chloride concentration is reached for a given solids content, whether a single site is used which settles to that solids content or a transfer of water is allowed such that the wastes reach that solids content

TABLE 29. TRANSFER OF CHLORIDE IN A GYPSUM UNDERDRAIN SYSTEM: SETTLING FROM 74% TO 80% SOLIDS

No. of Transfers[a]	Chloride Input		Chloride Output, ppm	
	Flue Gas, lb/min	Previous Pond Return, ppm	Scrubber Effluent	Pond Return
1	27.1	0	17,700	17,200
2	27.3	17,200	22,800	22,300
3	29.1	22,300	24,300	23,800
4	29.7	23,800	24,800	24,200
5	29.8	24,200	24,900	24,300
6	29.9	24,300	25,000	24,400
7	29.9	24,400	25,000	24,400

[a] After seven transfers, conditions remain the same.

TABLE 30. TRANSFER OF CHLORIDE IN AN LIME/LIMESTONE UNDERDRAIN SYSTEM: SETTLING FROM 55% TO 60% SOLIDS

No. of Transfers[a]	Chloride Input		Chloride Output, ppm	
	Flue Gas, lb/min	Previous Pond Return, ppm	Scrubber Effluent	Pond Return
1	21.1	0	7620	7430
2	25.0	7430	9020	8800
3	25.8	8800	9280	9060
4	25.9	9060	9330	9100
5	25.9	9100	9340	9110
6	25.9	9110	9340	9120
7	25.9	9120	9340	9120

[a] After seven transfers, conditions remain the same.

with drainage after filling. For example, the steady-state chloride concentration in the gypsum case is 24,400 mg/l for both initial settling to 80% solids and settling to 74% during filling, with transfer of drainage water from the previously filled site that had increased in solids content to 80% after filling was completed. It is important to note, however, that the ultimate solids content can be varied according to the final physical characteristics desired. As in the gypsum case, the underdrainage flow could be restricted to yield a final solids content of 68%, which was shown in Figure 11, to yield a very high load-bearing strength material (for gypsum without fly ash). It is also possible to allow complete free drainage and transfer of water and decrease the chloride concentration by water treatment, thus, reducing the chloride buildup within the scrubber system. While relatively high chloride concentrations (14,000 mg/l) do not appear to affect the scrubbing and oxidation process (Ref. 14), corrosion and pitting of unprotected scrubber systems (stainless steel) have been observed at chloride concentrations of 2000 mg/l (Ref. 15). Use of organic linings (e.g., rubber) or special alloys will be required to provide an effective barrier against corrosion.

Total Dissolved Solids Equilibrium

The composition and concentration of TDS in the effluent of a lime/limestone wet scrubbing system is determined by the interactions of chemical species originating in the lime or limestone, flue gas, fly ash, and process water. In addition, atmospheric O_2 and CO_2 interact with the system liquors where there is prolonged exposure such as in reaction tanks, holding tanks, and clarifiers. In the liquid phase of the recirculating system, solubility of each component is the primary factor that limits the equilibrium concentrations.

For dilute solutions, the solubility of the chemical species are relatively constant and independent of other ions in solution. The chloride salts, $CaCl_2$, NaCl, $MgCl_2$ and KCl, are extremely soluble (Ref. 16), and as assumed in the chloride balance section, will be completely dissolved. Other species such as calcium sulfate and calcium sulfite, which are the major products of the scrubbing process, will be in equilibrium with solid materials and their ions.

In the scrubbing process, the ionic concentration is no longer dilute, and there is a more complex equilibrium between the solid material, ions in solution, and atmospheric and scrubbing gases. One factor that becomes important as the total concentration of ions increases is the ionic strength of a solution. The presence in a solution of unrelated ions that are not involved in a particular chemical equilibrium can increase the solubility and, thus, the chemical equilibrium of the species of interest. The explanation for this effect is that the forces of attraction caused by the charges on the unrelated ions decrease the effective concentration of the soluble ions.

Another factor that becomes important in a multispecies equilibrium is the common ion effect. When species are present that contain a common ion, such as $CaSO_4$ and $MgSO_4$ or $CaCO_3$, the addition of a common ion results in a decrease in the solubility of the salt ($CaSO_4$) providing complex ions are not formed in appreciable concentrations. With an understanding of the interaction of the chemical species in the scrubber system and their solubilities, it is possible to calculate the equilibrium concentration of each species under conditions of the scrubber liquor. A minimum of analytical data is needed, normally consisting of the pH, ionic strength, temperature, atmospheric pressure of the gases, and the equilibrium concentration of only one principal species (see, for example, Ref. 5 or 17). The importance of this type of modeling is to demonstrate the interrelationships among the species and scrubber condition and to show that a large variance in the chloride content does not significantly alter the chemical equilibrium.

In typical scrubber systems, waste from the clarifier passes through a filter in which filter cake material is removed from the system and the filtrate is returned to the scrubber loop. In the same way, the underdrain disposal system filters and retains solid waste material and returns filtrate to the scrubber loop. Hence, the underdrain system does not alter the basic flow of the scrubber system and, therefore, should not affect the TDS/solid equilibrium. During the lifetime of the disposal site, filtrate will pass through a greater depth of material than typical filter systems. However, equilibrium should be maintained throughout the TDS/solid interface. In addition, it should also be noted that the flow through the waste material and underdrain system is only 1% of the total scrubber flow. Closure of a disposal site and transfer to a new site are equivalent to removing the filter cake from the filter, and equilibrium should be maintained. Since closure of a site temporarily increases the chloride concentration, as described in the previous sections, this increase could affect the ionic strength and the chemical equilibrium. A computer program described in Ref. 18 was used to illustrate the effect of this chloride increase on the major chemical species of the scrubber system. Table 31 lists the output of such a scrubber run, with input liquor concentration typical of Site J (gypsum with adipic acid added) and with chloride concentrations varied from the initial value of 6834 mg/l to an assumed value of 16,000 mg/l. This large chloride increase shows only a minor effect on the equilibrium concentrations; thus, any increase in TDS concentration is due to the addition of chloride to the scrubber system.

5.3.3 Conclusions

Analysis has shown that for ponds constructed so that the working section is the size required to accommodate nearly a 3-year supply (50 acres) of lime/limestone waste from a 1000-MWe station, the chloride concentration, being 5000 mg/l without underdrainage, would go to steady state at about 9340 mg/l. In contrast, a single gypsum disposal site that settled during filling to 80% solids would yield a Cl^- scrubber concentration of about 25,000 mg/l.

For a completely closed scrubber/disposal system, any water that drains from one disposal site after filling would be transferred to the next site. Each site would be closed in succession to disallow further infiltration of rainwater into the scrubber loop. An increase in chloride concentra-

TABLE 31. MODEL SIMULATION OF FGD SCRUBBER

Input[a]	Output, mg/l			
Cl^-	$SO_3^=$	$CO_3^=$	$SO_4^=$	Ca^{++}
6,834	108.6	0.666	1,147	3,750
10,000	108.7	0.661	1,203	3,749
13,000	108.8	0.656	1,254	3,748
16,000	108.0	0.652	1,303	3,748

[a] Input condition also included: Ca^{++}, 3,460 mg/l; Mg^{++}, 754 mg/l; Na^+, 188 mg/l; temperature, 298 K; SO_2 partial pressure, 1×10^{-7} atm; CO_2 partial pressure, 3.3×10^{-4} atm.

tion can be expected after each transfer due to the partial replacement of makeup water with drainage water from the previous site. The amount will depend upon the degree of settling and flow of the drainage. Water drainage from a gypsum disposal site settling from 74% solids to 80% solids over one 50-acre fill cycle (3.5 years) would yield a scrubber chloride concentration of about 22,800 mg/l in the second site. This concentration would increase slightly to a new steady-state concentration for each successive new site. After approximately seven transfers, a new overall steady-state chloride concentration of nearly 55,000 mg/l would be reached. The transfer from site to site for a lime/limestone scrubber system would be less severe, with an overall scrubber chloride concentration of about 9300 mg/l after seven transfers. Use of water from these disposal systems would require protection of the scrubber from corrosion.

The underdrain technique appears to offer several desirable advantages regarding environmental pollution control, as well as potential cost savings under specific conditions. It is important to note that the water balances described previously for gypsum disposal assumes that (1) an operational disposal site would settle as much as 6% in solids content, (2) the settling would only occur after filling is completed and the site covered with soil, (3) the entire pond will settle simultaneously, and (4) the permeability of the waste is such that the drainage would a occur during the time it would take to fill the next pond. All of those factors are variable and would affect the Cl^- steady state significantly. It is believed that the assumptions are conservative; however, an increase of just one order of magnitude in the permeability of the waste would change the draining time from 3.5 to 0.35 years. Such a change would significantly increase the equilibrium of the Cl^- concentration. For this case, a reduction of the return water would be required to maintain a suitable Cl^- concentration. Certain limiting conditions also are associated with this technique. The advantages and limitations in the application of underdrainage, as the method is now understood, are as follows:

Advantages

1. Dewatering equipment such as filters or clarifiers is not required; i.e., the waste may be sluiced to the disposal site, and the underdrainage system used to accomplish dewatering.

2. Utilization of the underdrain technique can reduce the amount of water retained and, hence, the amount of waste material that must be disposed of. For example, estimation of land requirement for the lime/limestone pond was reduced from 27 acres/yr (45% solids without underdrainage) to 20 acres/yr (60% solids with underdrainage) for a 1000-MW station.

3. The underdrain disposal system would tend to minimize the discharge of waste water and, under certain conditions, would result in a zero discharge since the water is returned to the

scrubber system. The use of recirculated water would also reduce the amount of fresh makeup water required.

4. Load-bearing strengths in excess of 60 psi for limestone waste and 135 psi for lime waste and gypsum develop in a few days. The material loses some strength when rewetted by rainfall but regains its strength again in a few days.

5. Under most conditions, a pond lining is not required because a hydraulic head of any consequence does not exist. With a gravity gradient on a few inches of water in the troughs that contain the drainage pipes, limitations on soil permeability and separation distance to the water table would need to be determined for a maximum of about 4 years operation before site closure.

6. Estimates of underdrainage disposal costs, in which the drainage blanket is delivered sand, place the cost for this system about midway between the costs for simple ponding without liners and chemical treatment. An underdrainage system has the potential for reduced cost if a drainage blanket of bottom ash and/or gravel, sand, and fly ash is used.

7. Underdrainage process is applicable to wastes containing fly ash or without fly ash.

Limitations

1. An underdrained basin may be limited in size due to construction limitation and operating efficiencies. Therefore, a modular approach may be required for the disposal site.

2. The disposal site must be reasonably close to the power plant to allow the installation of a pipeline.

3. It is recognized that a scrubber chloride concentration of 25,000 mg/l, which was projected for the gypsum case, is considerable and that an unprotected scrubber system could not be used. It appears that a lime/limestone sulfite-rich waste may be better suited for underdrainage disposal. However, waste which drains to a high solids content (e.g., gypsum) could be used if either the scrubbers were protected against the high chloride concentrations or water treatment was used to reduce the chloride in the water returned to the scrubber.

5.4 ENVIRONMENTAL ASSESSMENT OF FGD WASTE DISPOSAL

The principal objective of this study was to evaluate alternative methods for disposal of FGD wastes, emphasizing landfilling and ponding.

Throughout the major portion of this study there was an absence of appropriate Federal or other criteria relating to the disposal of these materials. Therefore drinking water criteria have been used as a basis for assessing disposal methods. Because some of the constituents analyzed exceeded the drinking water criteria, the approach taken in this study has been to consider disposal of the wastes such that no direct discharge to any water supply would be allowed and that any seepage would be minimized, or, perhaps, totally eliminated.

5.4.1 Disposal Alternatives

The FGD wastes that were evaluated were untreated, chemically treated, or force-oxidized to gypsum. Figure 52 illustrates the relationship of the FGD waste to the four disposal alternatives that were evaluated at Shawnee: pond disposal, underdrained disposal, landfill, and surface stacking. These categories of waste disposal and the considerations required for environmental control are listed in Table 32. In each case, potential seepage of rainwater through the waste and eventual contamination of ground water, runoff contamination, and land reclamation are the principal environmental concerns for the disposal methods. Consideration of each of these effects are given in the following discussions.

Pond Disposal

In general, the disposal of untreated material in a pond is usually the least costly (though not necessarily the most environmentally sound) approach to FGD waste disposal. Since untreated waste has a relatively high permeability, the seepage rate is controlled by the base material. Thus, this method requires a liner to be added to prevent seepage, if the pond does not contain a base material considered to be impermeable. Operationally, waste ponds exist today that contain either naturally impermeable soils or clay liners transported and placed in the base and on the slopes of the pond. Because of the highly thixotropic nature of these wastes, these ponds are nonstructural sites and generally are not considered to be easily reclaimed, except possibly in areas of low rainfall and high evaporation, where it may be possible upon retirement to air dry, cover, and vegetate the site. Also, if ponded wastes are not dewatered, larger land areas are needed to contain the material. As a result of chemically treating FGD wastes, the pollution potential of pond disposal is decreased because of a reduction in the wastes' permeability. Such reductions can be of one order of magnitude or greater. Because of the superior physical characteristics of the treated material, the pollution potential could be further reduced by sloping the treated waste to prevent collection of rainwater and covering the waste. In this case, the characteristics of the disposal site would be similar to the landfill disposal considered below.

Underdrain Disposal

Underdraining and collection of all seepage for return to the scrubber system maintains control of leachate at all times and has been shown at the Shawnee small-scale evaluation sites to produce a material structurally capable of supporting personnel and construction equipment. An operational

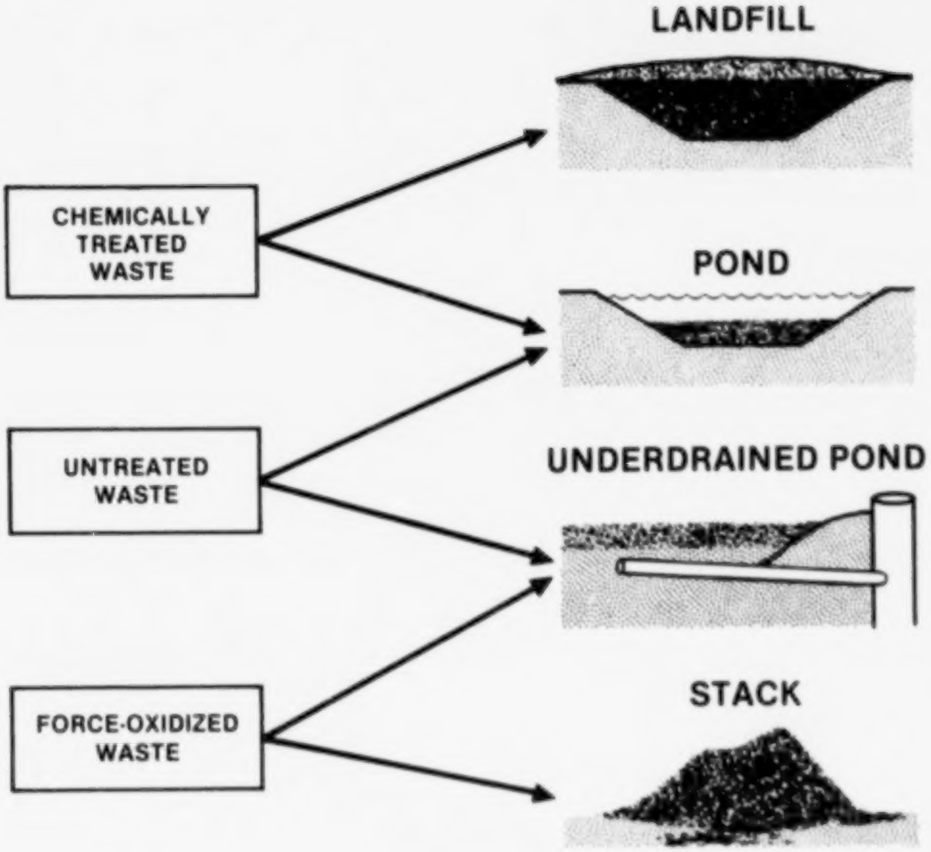

LANDFILL
CHEMICALLY TREATED WASTE
POND
UNTREATED WASTE
UNDERDRAINED POND
FORCE-OXIDIZED WASTE
STACK

Figure 52. FGD waste disposal alternatives

TABLE 32. ENVIRONMENTAL ASPECTS OF DISPOSAL ALTERNATIVES

Disposal	Condition of Waste	Primary Drainage	Land Reuse	Potential Problem Area	
				Seepage	Runoff
Land	Chemically Treated	None	Yes	No	No
Pond	Untreated	Supernate	No	Yes	No
Pond	Chemically Treated	Supernate	Yes	Yes	No
Underdrain Pond	Untreated or Conditioned[a]	Underdrainage	Yes	No	No
Stack	Conditioned	Runoff	No	Yes	Yes

[a] Conditioned waste refers to wastes treated by techniques other than chemical treatment and includes oxidation to gypsum and dewatering by mixing with dry fly ash or other agents.

site of this type collects rainfall via the seepage system and returns it to the scrubber. As a result it is necessary to limit the size of each disposal basin to maintain an acceptable water balance in the scrubber loop (Section 5.3). For a 1000-MW coal-burning utility site, this would be accomplished by dividing the site into sections of approximately 35 to 50 acres at a depth of about 30 ft. This type of disposal requires an earthen cap that is contoured and maintained to shed water after the disposal site is closed.

Landfill Disposal

Landfill disposal of stabilized chemically treated wastes offer a positive solution to the FGD waste disposal problem. It converts the waste to a structural material, decreases its coefficient of permeability a minimum of one order of magnitude better than untreated wastes, reduces the concentration of salt constituents in the leachate by approximately 50%, is amendable to subgrade or above-grade landfilling, and allows the disposal site to be reclaimed. Chemically treated wastes have not been shown to appreciably reduce concentration of trace elements in leachate, and, even though the concentration of major species is reduced, leaching of chemically treated sites should be avoided unless it can be assured that the leachate can be diluted by local ground water and streams. Chemically treated wastes that are disposed of in a landfill could be easily covered due to the structural stability of the material, and the land reclaimed. This would reduce the potential for water to leach through the material.

Surface Stack Disposal

The oxidization of FGD waste produces material that is readily dewatered by vacuum filtration or by centrifuging to a solids content in the range of 75 to 85% by weight. Leachate from gypsum is similar to that of untreated sulfite wastes and therefore should be prevented from entering water supplies. Stacked gypsum filter cake tends to form a protective surface crust capable of shedding rainwater, however, the filter cake may crack under freeze-thaw or wet-dry cycling, thereby allowing the entry of rainwater. The gypsum may erode when exposed to rainfall and produce a runoff containing potentially high concentrations of dissolved solids from the waste, as well as a condition that requires machinery to reconfigure the disposal pile after weathering and to control the runoff. In addition, surface stack disposal precludes land reclamation.

5.4.2 Disposal Regulations

During the period of performance of the early phase of this study, the Resource Conservation and Recovery Act (RCRA), Public Law 94-580, was enacted (October 1976). Under the provisions of this act, EPA is directed to provide regulations and guidance to control the disposal of hazardous and nonhazardous wastes including solid waste, which includes FGD wastes (air pollution control wastes). The EPA is also directed to develop a definition of hazardous wastes. Under most criteria, toxicity would undoubtedly be included and could pertain to FGD wastes. If these wastes are defined to be hazardous, the generation, transportation, and disposal would be controlled by EPA regulations as a minimum. If the wastes are determined to be nonhazardous, disposal would be controlled under the provisions of the RCRA land disposal program. EPA would produce disposal guidelines, but the responsibility for disposal would be that of the states.

At the present time, the "hazardous" definitions have been formulated under the new Hazardous Waste Management System (Ref. 19). Generally, a solid waste (consisting of either solids, liquids, or gaseous materials) is considered hazardous if the waste exhibits ignitable, corrosive, reactive, or toxic characteristics. The toxicity of the waste is determined by using an extraction procedure developed by EPA and designed to identify wastes likely to leach any of 17 toxic constituents in sufficient quantities to contaminate the ground water if the wastes are improperly managed. These contaminants are the same as those regulated under EPA drinking water standards and include arsenic, barium, cadium, chromium, lead, mercury, selenium, and silver. If the concentration of any of the contaminants in the waste extract is 100 times greater than the level specified in the drinking water regulations, the waste is considered hazardous.

According to the Hazardous Waste Management System, however, FGD wastes are temporarilly exempt from the management system. Nevertheless, a review of the concentration of the seepage from the leachates and underdrain system can be compared to the water quality criteria specified in the Hazardous Waste Management System. A comparison of the chemical constituents of waste leachates and underdrainage with these water quality regulations is given in Table 33. As shown, there are no measured values greater than the maximum concentration of contaminants allowed for a nonhazardous material.

As mentioned earlier, even if FGD waste were determined nonhazardous by the Hazardous Waste Management System (which was in response to Subtitle C of RCRA), these wastes are still subject to regulation under Subtitle D of RCRA, which relates to state or regional solid waste plans. Recent EPA regulations (Ref. 20) defined what solid waste disposal facilities and practices would pose a reasonable probability of an adverse effect on health or the environment. Such facilities would be classified as an "open dump" and thus prohibited under RCRA. The criteria for evaluation includes the facility effects on such items as flood plains, endangered species, surface water, ground water, land used for food-chain crops, disease, and air and safety management.

Surface and ground water criteria are of particular importance to FGD waste disposal. Disposal techniques that do not return water (e.g., underdrain or runoff) to the scrubber system or reprocessing facility and discharge these waters into streams or rivers are subject to the permit requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act.

All FGD waste disposal alternatives have some potential for ground water contamination, however, chemical treatment, underdrainage, and gypsum

TABLE 33. COMPARISON OF HAZARDOUS WATER QUALITY STANDARDS TO MAXIMUM POND LEACHATE AND UNDERDRAIN SAMPLES

Maximum Allowable Concentration for Nonhazardous Wastes (mg/l)		Maximum Concentration (mg/l) in Water Samples							
		Untreated Ponds		Chemically Treated Sites			Untreated Underdrained Sites		
		A	D	B	C	E	F	G	H
As	5.0 (.05)[a]	.037	1.0	.03	.033	.022	.008	.05	.012
Ba	100.0 (1.0)	1.5	2.5	1.5	1.0	2.2	4.0	2.0	3.4
Cd	1.0 (.01)	.04	.027	.03	.028	.031	.04	--	<.025
Cr	5.0 (.05)	.08	.11	.08	.03	.079	.04	.013	0.03
Pb	5.0 (.05)	0.04	.01	.08	.01	.078	.01	.03	.15
Hg	0.2 (.002)	.0011	.001	.007	.0012	.0004	.007	.001	.006
Se	1.0 (.01)	.007	.11	.2	.038	.002	.027	.008	.02
Ag	5.0 (.05)	<0.5	<0.5	<0.5	<0.5	.01	.013	.008	<0.05

--Not Determined

[a] Values in parentheses represent the National Interim Primary Drinking Water Regulations.

disposal with surface drainage reduce the possibility of seepage considerably. Under the provisions of RCRA, a facility shall not contaminate an underground drinking water source beyond the solid waste boundaries (projected in the horizontal plane). Contamination in this instance refers to introducing a substance that would cause the concentration of that substance in the ground water to exceed the maximum contaminant level or, namely, the National Interim Primary Drinking Water Regulations. As noted previously, only a few occasional leachate samples were in excess of these standards (Table 33).

A proposed amendment (Ref. 20) that would expand the list of maximum contaminant levels used in the ground water quality standards to include essentially the National Secondary Drinking Water Standard is being evaluated by EPA. Action in this area could significantly affect Federal regulations regarding FGD disposal since the major constituents in the waste leachate are covered in the secondary standards.

Table 34 gives a comparison of these secondary standards to the initial and long-term leachate or underdrain values. The initial values are estimates of the concentrations likely to occur during the filling operation (which for a large-scale site, could take several years), and long-term values represent typical values of leachates after placement for several years. Generally, values for sulfate and TDS are in excess of these standards during the filling process and in the long-term leachates. Typical concentrations of sulfate in the long-term leachates for the chemically treated and untreated wastes are approximately 1500 mg/l, or six times the secondary standards. The sulfate concentrations in the leachate are typically greater in the long-term. TDS values in the long-term leachates have concentrations of 1800 to 5000 mg/l, which are less than the initial filling concentrations. Chloride and pH are usually in excess of the standard during only the filling process. The metal ions listed appear to be typically less than the secondary standards, with the exception of manganese, which varies in concentration from 2 to 24 times the standard. Because of the high concentration of soluble salts in the leachates, ground water contamination under these proposed amendments would depend on the waste material permeability and the underlying soil (i.e., the rate at which the leachate could reach the ground water) and the volume of the leachate in comparison to the underground drinking water source.

TABLE 34. COMPARISON OF THE NATIONAL SECONDARY DRINKING WATER STANDARDS TO INITIAL AND LONG-TERM FGD WASTE WATER SAMPLES

Proposed Maximum Contaminate Level for Groundwater (mg/l)	Initial[a] and Long-Term[b] Concentrations of FGD Waste and Water Samples (mg/l)							
	Untreated Ponds		Chemically Treated Sites			Untreated, Underdrained Sites		
	A	D	B	C	E	F	G	H
Cl 250	4600 (5.0)	2950 (10)	940 (35)	2400 (75)	1000 (170)	2000 (300)	3600 (70)	3500 (1000)
Cu 1.0	— <0.1	— <0.1	— <0.1	— 0.1	— <0.1	— <0.1	— <0.05[c]	— <0.1[c]
Fe 0.3	— <0.1	— <0.1	— <0.1	— <0.1	— <0.1	— <0.1	— 0.5[c]	— <0.1[c]
Mn .05	— <0.1	— <0.1	— .5	— <0.5	— 0.3	— .7	— .3	— 1.2[c]
pH 6.5 - 8.5	8.3 (7.2)	9.2 (5.0)	10.1 (6.8)	11.9 (7.6)	11.2 (7.2)	12.2 (7.2)	7.8 (7.3)	7.1 (6.8)
SO_4 250	1530 (1450)	1500 (1600)	530 (1600)	750 (1450)	500 (1900)	1100 (1600)	6600 (900)	1930 (1600)
TDS 500	8560 (2300)	6750 (2300)	2600 (2600)	4700 (2350)	2900 (3500)	6700 (3400)	(14000) (1800)	9200 (5500)
Zinc 5.0	— <0.1	— <0.1	— <0.1	— 0.1	— 0.5	— .1	— <0.05	— 0.07[c]

[a] Initial concentrations are taken as the input value or the initial leachate samples and generally represents the maximum concentration during the site filling operation.

[b] Long-term concentration (given in parentheses) represents typical values of the most recent leachate or underdrain samples. See Table 1 for the time the sites have been under study.

[c] Based on only one sample.

SECTION 6

DISPOSAL COST ESTIMATES

6.1 BASE CONDITIONS

The costs for various FGD waste disposal alternatives are a function of many variables relating to the power plant, scrubber system, disposal systems, and economic factors. These include power plant location, plant size, load factor, boiler combustion characteristics, type of fuel burned, scrubber efficiency, limestone absorbent utilization, disposal site lifetime average annual capital charges, cost of land, depreciation of land and equipment, distance from power plant to disposal site, and dollar base year. Table 35 lists the values used for these variables in this analysis of two 500-MW units that burn bituminous coal in a generally midwestern location.

Cost estimates for six cases were derived from vendor estimates, previous Aerospace work, and other literature on this subject. These cost estimates differ slightly from those presented in the previous report on this project as a result of a revision upward in average unit capacity factors for the power stations and a reduction in disposal land costs. Based on a sampling of U.S. power companies and government agencies, the estimated cost of land was changed from \$5000 to \$2000/acre. Also, on the basis of recent data, the 30-year average unit capacity factor for new coal-fired utility power plants is now projected as 65% rather than 48.5%. The six cases examined are variations of two base cases. Table 36 is a summary of the two base case outputs for a limestone scrubber and a third for a similar scrubber in which the waste is oxidized to gypsum. These outputs are based on a model derived in a previous study (Ref. 21). The six cases are (1) untreated waste, indigenous clay liner; (2) untreated waste, synthetic liner; (3) untreated waste, underdrained; (4) gypsum, indigenous clay liner; (5) gypsum, synthetic liner; and (6) chemical treatment, indigenous soil. The costs for various disposal techniques were made using the quantities and costs for specific equipment and material for each variation. Costs for equipment and factors used to estimate the total cost are given in Table 37. The individual cases are discussed in Sections 6.2 through 6.8, and a summary of the annual disposal costs is given in Section 6.8. Appendix G contains derivations of the values for land, capacity factors, and synthetic liners used in the subsequent cost estimates.

6.2 UNTREATED WASTE, INDIGENOUS CLAY LINER

In this option, the limestone scrubber base conditions apply. As can be seen in Table 36, the 30-year average output of waste is 669 acre-ft/yr. The ponds are constructed in indigenous soil with earthen berms. The side

TABLE 35. SUMMARY OF BASE CONDITIONS FOR COST ESTIMATION

Item	Base Condition
Dollar Base	Mid-1980
Electric Utility Plant Size	Two 500 MW units
Coal Burned	3.5% sulfur 12,000 Btu/lb 14% fly ash
Heat Rate	9000 Btu/kWh
Annual Operating Hours	5694 (30-yr average for a 65% lifetime capacity factor)
Disposal Site Lifetime	30 yr
SO_2 Removal	90%
FGD Waste Generated	6.4×10^5 tons/yr, dry (general case) 6.6×10^5 tons/yr, dry (gypsum case)
Limestone Utilization	80% for limestone scrubbing; 100% for forced oxidation to gypsum
Annual Capacity Charges, 30-yr average	17%
Cost of Land Used for Disposal	$2000/acre
Disposal Site Location	Within one mile of steam plant
Total Disposal Area Requirements (including berm) for a 30-ft Waste Depth	
Chemically Treated Waste	650 acres
Force-Oxidized Waste	582 acres
Untreated Waste	
Lined	730 acres
Underdrained	780 acres

TABLE 36. SUMMARY OF LIME AND LIMESTONE SCRUBBER OUTPUT

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OUTPUT FORMAT FOR LIME AND LIMESTONE SCRUBBERS

 CASE  #- PROCESS TITLES AND OPTIONS
 % SULFUR  FUEL,BTU   FUEL %    CAPACITY    FUEL BTU ABSORBENT % SO2 REM  % MOIST
  IN FUEL   PER LB     ASH         MW       PER KWH  UTILIZ     BY SCRUB.   IN WST

 SULFITE-   DENSITY,  SODA ASH   PLANT
 TO SULFATE WET WASTE MAKE UP  OPERATING
  RATIO      LB/FT3       %       HOURS


 OUTPUT:
  FUEL       TOTAL       SO2       SO2       ABSORBENT    SO2        SO2        SO2
 BURNED,    SULFUR      FORMED    REMOVED      USED    EMISSIONS EMISSIONS LB/M BTU
   T/H        T/H         T/H       T/H         T/H       T/H        LB/H

   ASH      PRECIP
  FORMED    CaCO3       CaSO3       CaSO4      % ASH    % CaCO3   % CaSO3   % CaSO4
   T/H        T/H        T/H         T/H     DRY WASTE  DRY WASTE DRY WASTE DRY WASTE

   TOTAL       TOTAL     TOTAL       TOTAL    TOTAL WET  TOTAL WET  TOTAL
 DRY WASTE WET WASTE DRY WASTE WET WASTE  VOL,FT3/  VOL,ACRE   BTU/HR
   T/H         T/H       T/Y         T/Y      YEAR      FEET/YEAR


CASE      1- LIMESTONE SCRUBBER
     3.50    12000.      14.00       500.      9000.       80.00      90.00      50.00
   3.0:1.     88.60       0.0       5694.       0.0        80.00      15.00       2.00


OUTPUT:
  187.500      6.562     13.125     11.812     23.071      1.313      2625.      0.583
   26.250      4.614     17.857      7.937     46.331      8.144     31.518     14.008
   56.658    113.316 3.226E 05 6.452E 05 1.456E 07    334.361 4.500E 09


CASE      2- LIMESTONE SCRUBBER
     3.50    12000.      14.00       500.      9000.       80.00      90.00      50.00
   3.0:1.     88.60       0.0       7000.       0.0        80.00      15.00       2.00


OUTPUT:
  187.500      6.562     13.125     11.812     23.071      1.313      2625.      0.583
   26.250      4.614     17.857      7.937     46.331      8.144     31.518     14.008
   56.658    113.316 3.966E 05 7.932E 05 1.791E 07    411.052 4.500E 09


CASE      3- LIMESTONE SCRUBBER-GYPSUM CASE
     3.50    12000.      14.00       500.      9000.      100.00      90.00      35.00
   0.0:1.     87.36       0.0       5694.       0.0        80.00      15.00       2.00


OUTPUT:
  187.500      6.562     13.125     11.812     18.457      1.313      2625.      0.583
   26.250      0.0        0.0       31.746     45.262      0.0        0.0       54.738
   57.996     89.225 3.302E 05 5.080E 05 1.163E 07    267.013 4.500E 09


CASE      4- LIMESTONE SCRUBBER -GYPSUM CASE
     3.50    12000.      14.00       500.      9000.      100.00      90.00      35.00
   0.0:1.     87.36       0.0       7000.       0.0        80.00      15.00       2.00


OUTPUT:
  187.500      6.562     13.125     11.812     18.457      1.313      2625.      0.583
   26.250      0.0        0.0       31.746     45.262      0.0        0.0       54.738
   57.996     89.225 4.060E 05 6.246E 05 1.430E 07    328.256 4.500E 09
```

TABLE 37. WASTE DISPOSAL COMPONENT COSTS

Unit, Process, or Operation	Cost	Reference
	Capital Costs	
Earthwork	\$1.50/yd^3	16
Clearing	\$500/acre	16
Rip-Rap	\$20/yd^2	16
Lining (Hypalon-30 or equivalent) Installed	\$5.40/yd^2	21, Appendix G
Sand	\$4/ton	Conrock of Los Angeles,34
Gravel	\$4/ton	
Pumps:		
Limestone Case		
Water	\$34,010	17
Slurry	\$118,140	17
Gypsum Case		
Water	\$128,880	17
Slurry	\$408,120	17
Pipes:		
6-in. Diam.	\$12.74/ft	Imperial Pipe and Hood Corp., 35
8-in. Diam.	\$17.14/ft	
Electrical Equipment	\$81,740	18
Instruments:	\$115,900	18
Underdrained System	\$35/flow meter	22
Buildings	\$63,440	18
Fence	\$12.20/ft	18
Gypsum Oxidation Equipment		
Compressors	\$633,606	17
Tanks	\$14,692	17
Land	\$2,000/acre	Appendix G
Engineering	10%	--
Contingency	12%	--
Miscellaneous	0.5%	19
Startup and Modification	6.7%	19
Interest During Construction	1.6%	23
	Annual Costs	
Maintenance	4% capital equip.	18,19
Power	\$0.029/kWh	18,19
Labor and Supervision	\$17.05/hr	20
Analysis	\$17.00/hr	19

slopes of the berms are 2:1 (horizontal: vertical). A waste depth of 30 ft is used for all ponds, and a 3-ft freeboard is allowed. Perimeter and interior berms have a top width of 20 and 10 ft, respectively. Total land area required to construct the site is 230 acres, including land needed for berms and road beds (Figure 53).

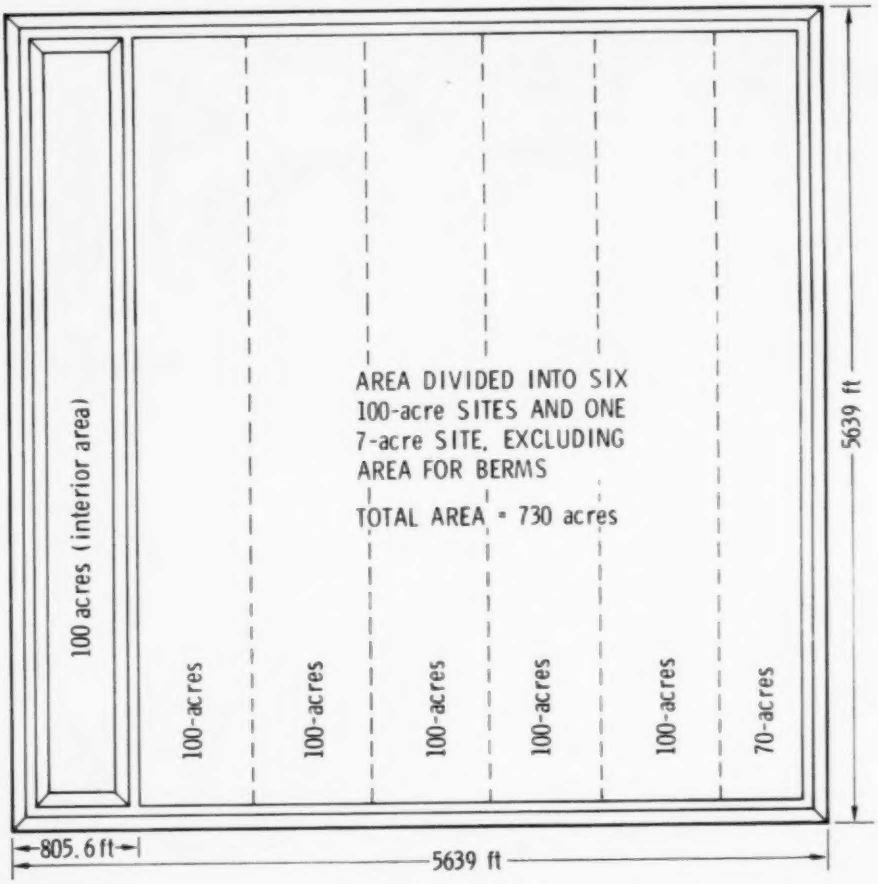
The slurried waste is pumped to the site from the power plant via a pipeline system consisting of one 8-in. pipe, which carries the waste to the pond and one 6-in. pipe, which returns water to the plant. Redundancy is supplied by an additional 8-in. pipe, one 6-in. pipe, and attendant pumps. Centrifugal pumps were considered. Table 38 lists the capital and annual operation and maintenance costs associated with this option. Table 39 shows the results of this cost estimate to be 0.51 mill/kWh, \$5.00/tonne of waste (dry), and \$1.51/tonne of coal. Capital investment is \$14.30/kWh.

6.3 UNTREATED WASTE, SYNTHETIC LINER

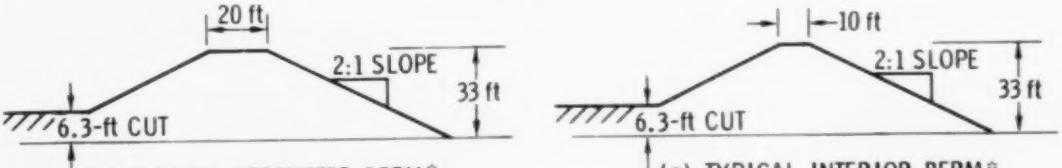
This case is very similar to the indigenous clay-lined pond. Pond sizes and other equipment such as pumps and pipes are identical. There is an additional capital cost of \$18,700,000 for liner material (such as 30-mil Hypalon at \$5.40/yd^2, installed). Tables 40 and 41 show the cost computations and results for this case. The liner affects the disposal cost significantly, increasing it from 0.5 mill/kWh in the indigenous clay liner case to \$1.23 mills/kWh for the elastomeric-lined case.

6.4 UNTREATED WASTE, UNDERDRAINED

For the underdrain design, a maximum site module of about 50 acres was chosen. Although this disposal technique can accommodate larger sections, this size was chosen to simplify the underdrainage system, with an adjacent site acting as a backup unit. In effect, two sites would always be available with separate but connecting plumbing systems. When the first one is filled (after about 2 years) and capped with clay, a third site would be put into service, and the second site would become the primary active unit - and so on (Figure 54). With smaller sites, more berms are required and, thus, more land and earthwork. Compared to undrained, indigenous clay-lined ponds, costs are increased because of the need for a porous base (sand, gravel, and bottom ash) and additional pipes and fittings. With this type of system, under most conditions a liner is not required even for soils with a permeability coefficient as large as 10^{-5} cm/sec. For this approach, then, the porous base is a significant factor, about 33%, of the capital costs (Table 42). Therefore, a site designed for a minimum sand bed depth will generally result in the minimum cost design for this type of disposal. The thinner the porous bed the greater the number of drainage pipes that would be required, but because of the comparatively high cost of porous bed compared to pipe installation the thinner bed appears to be more appropriate. The variation of drainage pipe spacing as a function of porous bed depth is discussed in Section 5.3.1. Estimates for disposal costs for the underdrained, untreated case are 0.86 mill/kWh, \$8.32/tonne waste (dry), and \$2.51/tonne coal (Table 43). These are approximately 70% higher than for the untreated site with an indigenous clay


100 acres (interior area)
AREA DIVIDED INTO SIX
100-acre SITES AND ONE
7-acre SITE, EXCLUDING
AREA FOR BERMS
TOTAL AREA = 730 acres
100-acres
100-acres
100-acres
100-acres
100-acres
70-acres
5639 ft
805.6 ft
5639 ft

(a) PLAN VIEW


20 ft
2:1 SLOPE
33 ft
6.3-ft CUT
10 ft
2:1 SLOPE
33 ft
6.3-ft CUT

(b) TYPICAL PERIMETER BERM*

(c) TYPICAL INTERIOR BERM*

*Not to scale

Figure 53. Limestone scrubbing waste pond: 100-acre pond area

TABLE 38. COST ESTIMATE FOR UNTREATED POND INDIGENOUS LINER (SIX 100-ACRE PONDS PLUS ONE 70-ACRE POND)

Capital Cost		
Construction		
Clearing (730 acres @ \$500/acre)		\$ 365,000
Cut/Embankment (5,053,415 yd^3 @ \$1.50/yd^3)		7,580,000
Rip-Rap (40,552 yd^2 @ \$20/yd^2)		811,000
Equipment		
Process (pumps)		304,000
Pipes (2-mi, 8-in. pipe and 2-mi, 6-in. pipe)		316,000
Electrical		82,000
Instrumentation		116,000
Building/Fencing (26,121-ft fence)		382,000
Total Capital Costs plus Equipment		9,960,000
Engineering (10%)		996,000
Miscellaneous Services (0.5%)		49,800
		11,000,000
Contingency (12%)		1,320,000
		12,300,000
Startup and Modification Allowance (6.7%)		824,000
Interest During Construction (1.6%)		197,000
Land (730 acres @ \$2,000/acre)		1,460,000
	Total	\$14,800,000
Operation & Maintenance (O&M) Costs		
First Year O&M Costs:		
Maintenance (4% of capital equipment)		\$ 48,000
Power		24,100
Labor and Supervision		149,000
Analysis (1000 hr @ \$17/hr)		17,000
		\$ 238,000

TABLE 39. COMPUTATION OF LEVELIZED COSTS FOR UNTREATED POND, INDIGENOUS LINER

Average Annual Capital Charges $K = 0.17$

Life of Installation $N = 30$

Capital Recovery Factor $CRF = 0.17 \; \{CRF = K/[1-(1+K)^{-N}]\}$

Levelized Capital Cost = CRF x Capital Cost = 0.17 ($14,800,000) = $2,520,000

Inflation Rate $g = 0.07$

Average Annual O&M Charges $K' = 0.09 \; [K' = (K-g)/(1+g)]$

O&M Capital Recovery Factor $CRF' = 0.10 \; \{CRF' = K'/[1-(1+K')^{-N}]\}$

Levelized O&M Cost = (O&M cost/CRF) x CRF' = $405,000

Total Levelized Cost = $2,520,000 + $405,000 = $2,930,000

$$\frac{\$2,930,000 \times 1000}{5.69 \times 10^{9} \text{ kWh}} = \$\ 0.51 \text{ mills/kWh}$$

$$\frac{\$2,930,000}{6.45 \times 10^{5} \text{ tons waste, dry basis}} = \$\ 4.54\text{/ton waste, dry basis}$$

$$\frac{\$2,930,000}{\frac{0.75 \text{ lb}}{\text{kWh}} \times \frac{\text{ton}}{2000 \text{ lb}} \times 5.69 \times 10^{9} \text{ kWh}} = \$\ 1.37\text{/ton coal}$$

$$\frac{\$14,800,000}{1,000,000 \text{ kW}} = \$14.80\text{/kW}$$

TABLE 40. COST ESTIMATE FOR UNTREATED POND SYNTHETIC LINER (SIX 100-ACRE PONDS PLUS TWO 35-ACRE PONDS)

Capital Costs		
Construction		
Clearing (730 acres @ \$500/acre)		\$ 365,000
Cut/Embankment (5,053,415 yd^3 @ \$1.50 yd^3)		7,580,000
Synthetic Liner (3,458,820 yd^2 @ \$5.40/yd^2)		18,700,000
Equipment		
Process (pumps)		304,000
Pipes (2-mi, 8-in. pipe and 2-mi, 6-in. pipe)		316,000
Electrical		82,000
Instrumentation		116,000
Building/Fencing (26,121-ft fence)		382,000
		27,800,000
Engineering (10%)		2,780,000
Miscellaneous Services (0.5%)		139,000
		30,700,000
Contingency (12%)		3,680,000
		34,400,000
Startup and Modification Allowance (6.7%)		2,300,000
Interest During Construction (1.6%)		550,000
Land (730 acres @ \$2000/acre)		1,460,000
	Total	\$38,700,000
Operation & Maintenance (O&M) Costs		
First Year O&M Costs:		
Maintenance (4% of capital equipment)		\$ 48,000
Power		24,100
Labor and Supervision		149,000
Analysis (1000 hr @ \$17/hr)		17,000
		\$ 238,000

TABLE 41. COMPUTATION OF LEVELIZED COSTS FOR UNTREATED POND, SYNTHETIC LINER

Average Annual Capital Charges K = 0.17

Life of Installation N = 30

Capital Recovery Factors CRF = 0.17

Levelized Capital Cost = CRF x Capital Cost = 0.17 ($38,700,000) = $6,580,000

Inflation Rate g = 0.07

Average Annual O&M Charges K' = 0.09

O&M Capital Recovery Factor CRF' = 0.10

Levelized O&M Cost = (O&M cost/CRF') x CRF = $405,000

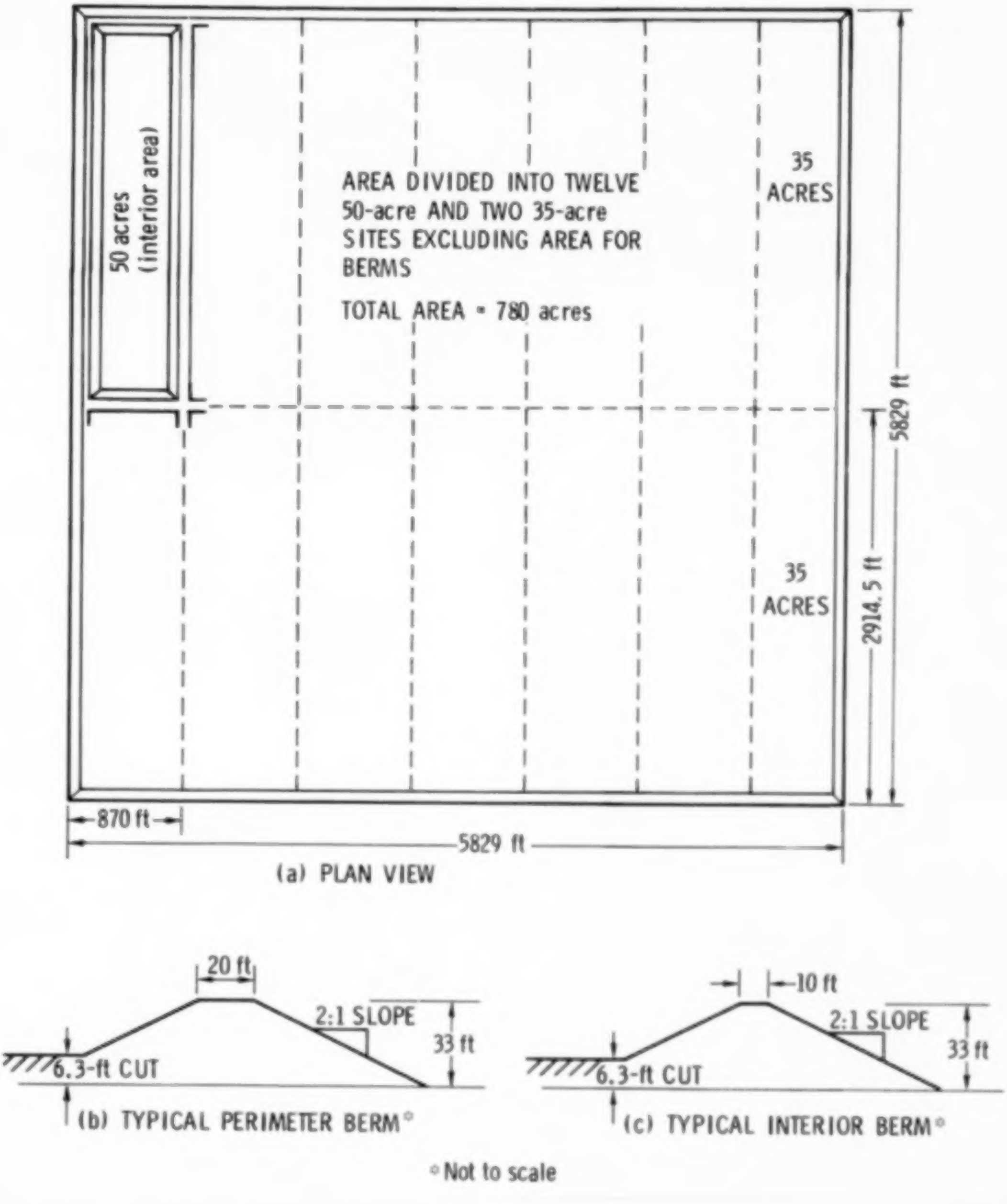
Total Levelized Cost = $6,580,000 + $405,000 = $6,990,000

$$\frac{\$6,990,000 \times 1000}{5.69 \times 10^9 \text{ kWh}} = \$\ 1.23 \text{ mills/kWh}$$

$$\frac{\$6,990,000}{6.45 \times 10^5 \text{ tons waste, dry basis}} = \$10.84\text{/ton waste, dry basis}$$

$$\frac{\$6,990,000}{\frac{0.75 \text{ lb}}{\text{kWh}} \times \frac{\text{ton}}{2000 \text{ lb}} \times 5.69 \times 10^9 \text{ kWH}} = \$\ 3.28\text{/ton coal}$$

$$\frac{\$38,700,000}{1,000,000 \text{ kW}} = \$38.70\text{/kW}$$



50 acres
(interior area)
AREA DIVIDED INTO TWELVE
50-acre AND TWO 35-acre
SITES EXCLUDING AREA FOR
BERMS
TOTAL AREA = 780 acres
35
ACRES
35
ACRES
5829 ft
2914.5 ft
870 ft
5829 ft
(a) PLAN VIEW
20 ft
2:1 SLOPE
33 ft
6.3-ft CUT
(b) TYPICAL PERIMETER BERM°
10 ft
2:1 SLOPE
33 ft
6.3-ft CUT
(c) TYPICAL INTERIOR BERM°
°Not to scale

Figure 54. Limestone scrubbing waste pond: 50-acre sections for underdrainage

TABLE 42. COST ESTIMATE FOR UNTREATED WASTE UNDERDRAINED SITE

Capital Costs	
Construction	
Clearing (780 acres @ $500/acre)	$ 390,000
Cut/Embankment (5,993,208 yd^3 @ $1.50/yd^3)	8,990,000
Rip-Rap (43,282 yd^2 @ $20/yd^2)	866,000
Sand (1,540,779 tons @ $4.00/ton)	6,160,000
Gravel (20,866 tons @ $4.00/ton)	83,500
Equipment	
Process (pumps)	304,000
Pipes ($581,857 for underdrain + 2-mi, 8-in. pipe and 2-mi, 6-in. pipe)	898,000
Electrical	82,000
Instrumentation (10 flow meters included)	117,000
Building/Fencing (26,935-ft fence)	392,000
	18,300,000
Engineering (10%)	1,830,000
Miscellaneous Services (0.5%)	91,500
	20,200,000
Contingency (12%)	2,420,000
	22,600,000
Startup and Modification Allowance (6.7%)	1,510,000
Interest During Construction (1.6%)	362,000
Land (780 acres @ $2000/acre)	1,560,000
Total	$26,000,000
Operation & Maintenance (O&M) Costs	
First Year O&M Costs:	
Maintenance (4% of capital equipment)	$ 71,700
Power	24,100
Labor and Supervision	149,000
Analysis (1000 hr @ $17/hr)	17,000
	$ 262,000

TABLE 43. COMPUTATION OF LEVELIZED COSTS FOR UNTREATED WASTE, UNDERDRAINED

Average Annual Capital Charges K = 0.17

Life of Installation N = 30

Capital Recovery Factor CRF = 0.17

Levelized Capital Cost = CRF x Capital Cost = 0.17 ($26,000,000) = $4,420,000

Inflation Rate g = 0.07

Average Annual O&M Charges K' = 0.09

O&M Capital Recovery Factor CRF' = 0.10

Levelized O&M Cost = (O&M cost/CRF') x CRF = $445,000

Total Levelized Cost = $4,420,000 + $445,000 = $4,870,000

$$\frac{\$4,870,000 \times 1000}{5.69 \times 10^{9} \text{ kWh}} = \$\ 0.86 \text{ mills/kWh}$$

$$\frac{\$4,870,000}{6.45 \times 10^{5} \text{ tons waste, dry basis}} = \$\ 7.55\text{/ton waste, dry basis}$$

$$\frac{\$4,870,000}{\frac{0.75 \text{ lb}}{\text{kWh}} \times \frac{\text{ton}}{2000 \text{ lb}} \times 5.69 \times 10^{9} \text{ kWh}} = \$\ 2.28\text{/ton coal}$$

$$\frac{\$26,000,000}{1,000,000 \text{ kW}} = \$26.00\text{/kW}$$

liner and about 30% less than for disposal of untreated waste in an elastomeric-lined site (Section 6.8).

6.5 GYPSUM, INDIGENOUS CLAY LINER

Two gypsum cases were examined in which gypsum slurry is pumped to the disposal site: one indigenously lined and the other synthetically lined. For this alternative, the waste is oxidized to gypsum by means of an integrated forced-oxidation system. A 15% solids slurry is pumped to the disposal site, where the gypsum settles to approximately 65% solids. Since less gypsum waste at 65% solids is produced than limestone waste at 50% solids, a smaller gypsum pond size is required. A sketch of a gypsum site is shown in Figure 55. The land area required is 582 acres for ponds containing settled gypsum at a depth of 30 ft. This acreage accounts for berms and road beds.

The waste is slurried to the pond through a system of four parallel 8-in. pipes. Return water to the scrubber loop is piped through two 8-in. pipes. Redundancy is supplied by six additional 8-in., two-way pipes. The other major capital expenditure in this alternative is the cost of the oxidation itself, e.g., compressors, tanks, and lines: $6,100,000. Some cost is saved by the reduction in land requirements because the material is disposed of with less water than in the limestone system. The estimates for the disposal cost for gypsum waste slurried to a pond with indigenous liner is given in Tables 44 and 45. The total costs are approximately 55% greater than for untreated disposal in an indigenous clay-lined site, the increase being attributable primarily to the oxidation process.

6.6 GYPSUM, SYNTHETIC LINER

This case is similar to the other gypsum case with the addition of a $14,000,000 capital investment to install a liner at $5.40/yd^2. The liner represents about 48% of the total capital cost. Tables 46 and 47 contain cost estimates of this gypsum disposal option. The annual disposal cost of 1.28 mills/kWh, $12.21/tonne dry waste, and $3.78/tonne coal, are about 60% higher than for gypsum disposed of in an indigenous clay-lined site, the increased cost being due to the synthetic liner.

6.7 CHEMICAL TREATMENT

Costs for chemical treatment were developed by adjusting previous Aerospace estimates (Ref. 1) to present the value and base conditions stated in Table 35 Current average land values as discussed in Section 6.1 are reflected in these estimates, as are actual operating costs (Ref. 32). Although capital costs in relation to previous estimates declined as a result of the land and capacity factor revisions dicated earlier (Section 6.1), they were offset by the inclusion of capital investment contingency, startup, and modification costs and interest during construction that were not included in previous estimates (Table 48). All these factors were applied to the untreated and gypsum disposal costs, and therefore all costs are on a comparable basis in this study.

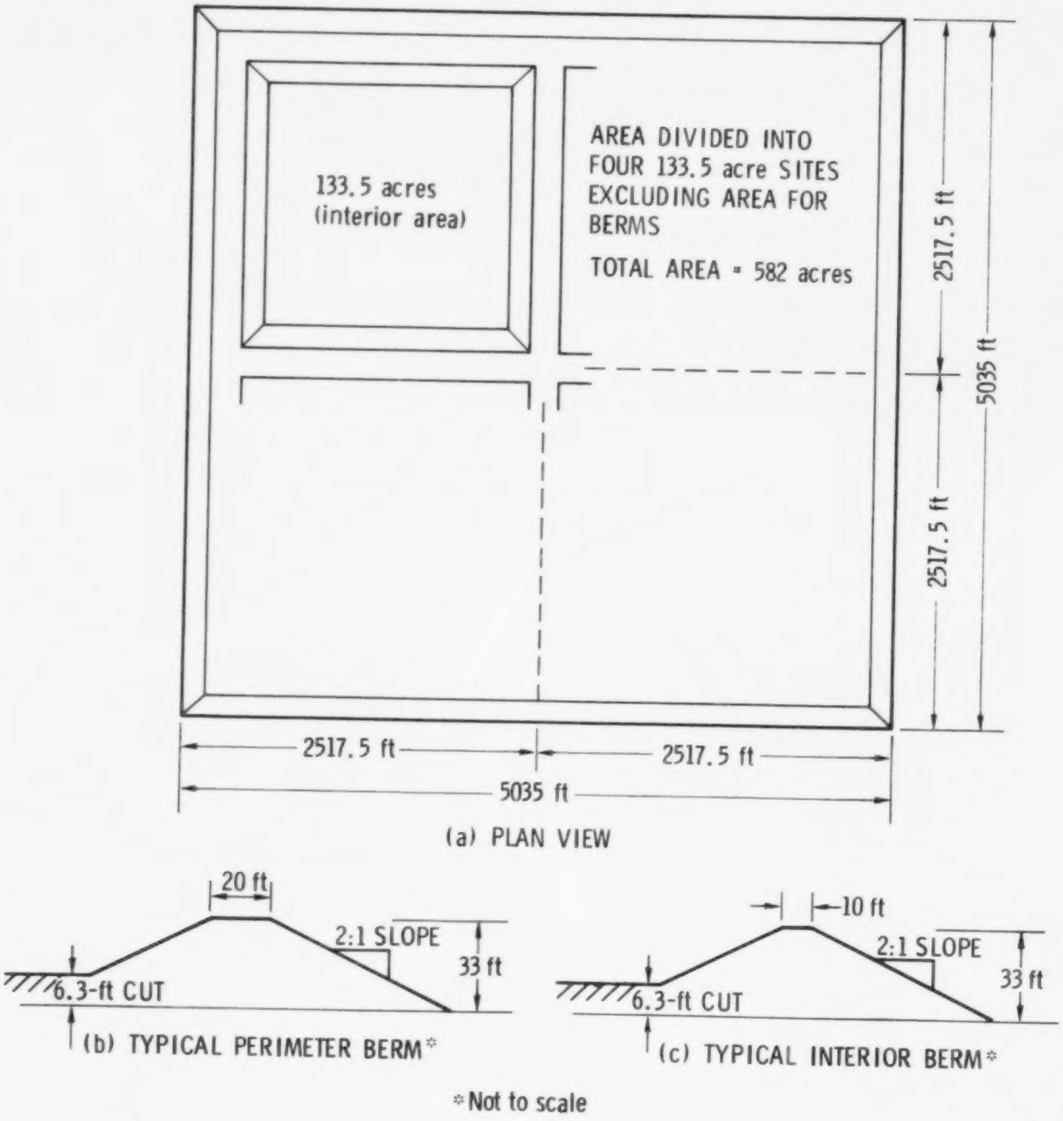

133.5 acres
(interior area)
AREA DIVIDED INTO FOUR 133.5 acre SITES EXCLUDING AREA FOR BERMS
TOTAL AREA = 582 acres
2517.5 ft
2517.5 ft
5035 ft
2517.5 ft
2517.5 ft
5035 ft
(a) PLAN VIEW
20 ft
2:1 SLOPE
33 ft
6.3-ft CUT
(b) TYPICAL PERIMETER BERM*
10 ft
2:1 SLOPE
33 ft
6.3-ft CUT
(c) TYPICAL INTERIOR BERM*
*Not to scale

Figure 55. Gypsum waste pond: 133.5-acre pond area

TABLE 44. COST ESTIMATE FOR SLURRIED GYPSUM

Capital Costs		
Construction		
Clearing (582 acres @ $500/acre)		$ 241,000
Cut/Embankment (4,349,155 yd^3 @ \$1.50/yd^3)		6,520,000
Rip-Rap (28,772 yd^2 @ \$20/yd^2)		575,000
Equipment		
Process (slurry pumps + oxidation equipment)		6,100,000
Pipes (12-mi, 8-in. pipe)		1,090,000
Electrical		82,000
Instrumentation		116,000
Building/Fencing (23,087-ft fence)		86,500
		14,900,000
Engineering (10%)		1,490,000
Miscellaneous Services (0.5%)		74,500
		16,500,000
Contingency (12%)		1,980,000
		18,500,000
Startup and Modification Allowance (6.7%)		1,240,000
Interest During Construction (1.6%)		296,000
Land (582 acres @ $2000/acre)		1,160,000
	Total	$21,200,000
Operation and Maintenance (O&M) Costs		
First Year O&M Costs:		
Maintenance (4% of capital equipment)		$ 299,000
Power		214,000
Labor and Supervision		149,000
Analysis (1000 hr @ $17/hr)		17,000
		$ 380,000

TABLE 45. COMPUTATION OF LEVELIZED COSTS FOR SLURRIED GYPSUM, INDIGENOUS LINER

Average Annual Capital Charges K = 0.17

Life of Installation N = 30

Capital Recovery Factor CRF = 0.17

Levelized Capital Cost = CRF x Capital Cost = 0.17 ($21,200,000) = $3,600,000

Inflation Rate g = 0.07

Average Annual O&M Charges K' = 0.09

O&M Capital Recovery Factor CRF' = 0.10

Levelized O&M Cost = (O&M cost/CRF') x CRF = $646,000

Total Levelized Cost = $3,600,000 + $646,000 = $4,250,000

$$\frac{\$4{,}250{,}000 \times 1000}{5.69 \times 10^{9}\ \text{kWh}} = \$\ 0.79\ \text{mills/kWh}$$

$$\frac{\$4{,}250{,}000}{6.60 \times 10^{5}\ \text{tons waste, dry basis}} = \$\ 6.44/\text{ton waste, dry basis}$$

$$\frac{\$4{,}250{,}000}{\frac{0.75\ \text{lb}}{\text{kWh}} \times \frac{\text{ton}}{2000\ \text{lb}} \times 5.69 \times 10^{9}\ \text{kWh}} = \$\ 1.99/\text{ton coal}$$

$$\frac{\$21{,}200{,}000}{1{,}000{,}000\ \text{kW}} = \$21.20/\text{kW}$$

TABLE 46. COST ESTIMATE FOR SLURRIED GYPSUM SYNTHETIC LINER

Capital Costs		
Construction		
Clearing (582 acres @ \$500/acre)		\$ 291,000
Cut/Embankment (4,349,155 yd^3 @ \$1.50/yd^3)		6,520,000
Synthetic Liner (2,588,126 yd^2 @ \$5.40/yd^2)		14,000,000
Equipment		
Process (slurry pumps + oxidation equipment)		6,100,000
Pipes (12-mi, 8-in. pipe)		1,090,000
Electrical		82,000
Instrumentation		116,000
Building/Fencing (23,087-ft fence)		86,500
		28,300,000
Engineering (10%)		2,830,000
Miscellaneous Service (0.5%)		142,000
		31,300,000
Contingency (12%)		3,760,000
		35,100,000
Startup and Modification Allowance (6.7%)		2,350,000
Interest During Construction (1.6%)		562,000
Land (582 acres @ \$2000/acre)		1,160,000
	Total	\$39,200,000
Operation & Maintenance (O&M) Costs		
First Year O&M Costs:		
Maintenance (4% of capital equipment)		\$ 299,000
Power		214,000
Labor and Supervision		149,000
Analysis (1000 hr @ \$17/hr)		17,000
		\$ 380,000

TABLE 47. COMPUTATION OF LEVELIZED COSTS FOR SLURRIED GYPSUM, SYNTHETIC LINER

Average Annual Capital Charges K = 0.17
Life of Installation N = 30
Capital Recovery Factor CRF = 0.17
Levelized Capital Cost = CRF x Capital Cost = 0.17 ($39,200,000) = $6,660,000

Inflation Rate g = 0.07
Average Annual O&M Charges K' = 0.09
O&M Capital Recovery Factor CRF' = 0.10
Levelized O&M Cost = (O&M Cost/CRF') x CRF = $646,000
Total Levelized Cost = $6,600,000 + $646,000 = $7,310,000

$$\frac{\$7{,}310{,}000 \times 1000}{5.69 \times 10^{9} \text{ kWh}} = \$\ 1.28 \text{ mills/kWh}$$

$$\frac{\$7{,}310{,}000}{6.60 \times 10^{5} \text{ ton waste, dry basis}} = \$11.08\text{/ton waste, dry basis}$$

$$\frac{\$7{,}310{,}000}{\frac{0.75 \text{ lb}}{\text{kWh}} \times \frac{\text{ton}}{2000 \text{ lb}} \times 5.69 \times 10^{9} \text{ kWh}} = \$\ 3.43\text{/ton coal}$$

$$\frac{\$39{,}200{,}000}{1{,}000{,}000 \text{ kW}} = \$39.20\text{/kW}$$

TABLE 48. CHEMICALLY TREATED WASTE DISPOSAL COST UPDATE

Average Annual Cost	1980 $12.84/ton waste, dry basis 1.46 mills/kWh $3.88/ton coal
Capital Investment	1980 $17,780,000 $17.78/kW

Table 49 summarizes the results for this disposal alternative. A major difference between this method and the underdrain approach is that only one large site is needed for chemically treated waste since the treated material after curing and disposal has structural properties and does not require interior earthen berms to contain it. One large site reduces land requirements by about 17%, thereby reducing land requirements and site preparation costs.

The disposal of chemically treated FGD wastes that are in the form of a low permeability, structural material was estimated as 1.46 mills/kWh, \$14.15/tonne dry waste, and \$4.28/tonne coal burned. Major cost items relative to untreated disposal include chemical reagents, slurry dewatering equipment, and transport and placement of the treated waste in the disposal site.

6.8 COST COMPARISONS

The costs for the six disposal alternatives discussed are listed in Table 50 in units of dollars per ton of dry waste, dollars per ton of coal, and mills per kilowatt hour in mid-1980 dollars. Also listed is the capital cost comparison in dollars per kilowatt hour. In all cases, the cost includes disposal of ash in the waste.

TABLE 49. CONTINGENCY AND MISCELLANEOUS CAPITAL INVESTMENT COSTS

Item	Cost
Engineering	10% of capital equipment
Miscellaneous Services	0.5% of capital equipment
Contingency	12% of capital equipment, plus engineering, and miscellaneous services
Startup and Modification Allowance	6.7% of capital equipment, plus all of the items listed above
Interest During Construction[a]	1.6% of capital equipment, plus all of the items listed above

[a] Estimated as 4 months.

TABLE 50. COST COMPARISON OF DISPOSAL ALTERNATIVES (MID-1980 DOLLARS)

Disposal	Annual Disposal Costs[c]			Capital Investment Cost	
	Mills/kWh	$/Tonne of Dry Waste	$/Tonne of Coal	$/kW	Significant Cost Items[b]
Untreated Waste Pond Indigenous Liner	0.51	5.01	1.51	14.80	Land (780 acres)
Synthetic Liner (Polymeric)	1.23	11.96	3.62	38.70	Land and liner
Betonite Clay Liner	2.06	20.01	6.04	66.20	Land, clay liner, and clay transportation
Volclay SS-100 Liner	0.94	9.13	2.76	29.00	Land and liner
Underdrained	0.86	8.33	2.51	26.00	Land and underdrainage system
Force-Oxidized Waste with Surface Drainage					
Indigenous Liner	0.79	7.10	2.19	21.20	Oxidation equipment
Synthetic Liner (Polymeric)	1.28	12.22	3.78	39.20	Oxidation equipment and synthetic liner
Chemically Treated Waste Landfill	1.46	14.16	4.78	17.78	Dewatering equipment and chemical reagents

[a] Cost comparisons are for conditions summarized in Tables 38 through 48 and cost factors in Tables 35, 37, and 49.

[b] Relative to the various alternatives presented.

[c] Includes disposal of ash in the waste.

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APPENDIX A

ORGANIZATION AND MANAGEMENT

This project was managed by the U.S. Environmental Protection Agency (EPA) Industrial Environmental Research Laboratory, Research Triangle Park, North Carolina. The functional relationships of the organizations participating in the project are shown in Figure A-1.

The Aerospace Corporation was responsible for project planning and coordination, preparation of project test plans, laboratory analyses of waste materials and selected water samples, preparation of engineering cost estimates for the disposal processes being evaluated, assessment of all analytical results, and reporting of project activities and analytical results.

The Tennessee Valley Authority (TVA) was responsible for all construction, filling of untreated ponds, supplying wastes to the chemical treatment processor at the site, site maintenance, sampling and analyses, sample distribution, climatological and hydraulic data collection, photographic documentation (still and motion pictures), and contracting with waste treatment processors. TVA also provided analytical data, climatological and hydraulic data, and photographic documentation to The Aerospace Corporation for assessment and inclusion in formal reporting to EPA, as well as scrubber data as necessary.

The processors who have chemically treated wastes now under evaluation are Chemfix, Inc., and Dravo Corporation, Pittsburg, Pennsylvania and IU Conversion Systems, Inc., Philadelphia, Pennsylvania.

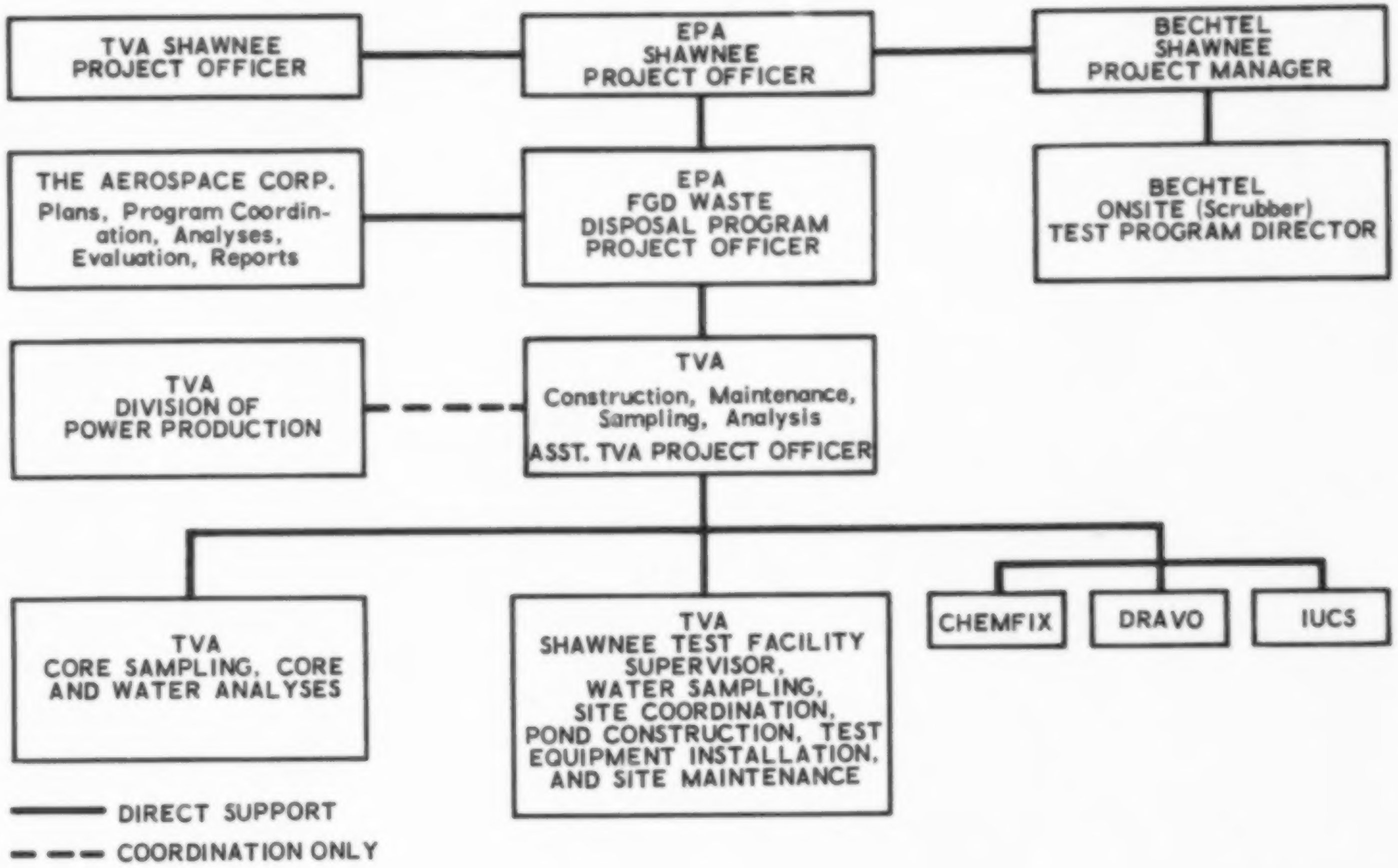
TVA SHAWNEE PROJECT OFFICER
EPA SHAWNEE PROJECT OFFICER
BECHTEL SHAWNEE PROJECT MANAGER
THE AEROSPACE CORP. Plans, Program Coordination, Analyses, Evaluation, Reports
EPA FGD WASTE DISPOSAL PROGRAM PROJECT OFFICER
BECHTEL ONSITE (Scrubber) TEST PROGRAM DIRECTOR
TVA DIVISION OF POWER PRODUCTION
TVA Construction, Maintenance, Sampling, Analysis ASST. TVA PROJECT OFFICER
TVA CORE SAMPLING, CORE AND WATER ANALYSES
TVA SHAWNEE TEST FACILITY SUPERVISOR, WATER SAMPLING, SITE COORDINATION, POND CONSTRUCTION, TEST EQUIPMENT INSTALLATION, AND SITE MAINTENANCE
CHEMFIX
DRAVO
IUCS
DIRECT SUPPORT
COORDINATION ONLY

Figure A-1. EPA Shawnee FGD waste disposal field demonstration functional organization

APPENDIX B

SITE AND FACILITY DESCRIPTION

B.1 GENERAL

The FGD waste disposal evaluation site is located on the Tennessee Valley Authority (TVA) property at the TVA Shawnee Steam Plant near Paducah, Kentucky. The Shawnee plant has 10 generating units with a total capacity of 1,750,000 kW of electric power. At its typical level of operation, Shawnee consumes 4,500,000 tons/yr of bituminous coal from western Kentucky and Illinois.* This coal has an average sulfur content of approximately 3.5%.

B.2 TEST FACILITIES

The FGD wastes being evaluated on this project were obtained from two prototype wet lime/limestone scrubbers operating in parallel on Shawnee boiler No. 10, each capable of treating approximately 30,000 ft^3/min (at 300°F) of flue gas.† Gas that is ash-free, or containing ash, may be fed to either scrubber. The two scrubbers, each of which treats an equivalent of 10 MW of boiler capacity, produce an effluent slurry containing sulfite, sulfate, chloride, calcium, and trace elements. The effluent is pumped to a thickener area from which water can be removed by means of a clarifier, centrifuge, or filter prior to placement of the waste in one of the disposal areas. Both treated and untreated wastes were analyzed in the program.

B.3 DISPOSAL AREAS

The disposal areas are identified as Sites A1, B, C, D, E, F, G, H, J, and K. These areas are shown in relationship to the power plant in Figure B-1. The disposal sites were constructed in accordance with the dimensions shown in Table B-1. All berms are contoured to drain away from the sites. No compaction of the sides or bottom of the disposal sites was performed other than that resulting from the operation of earth moving equipment incidental to constructing the sites. The bottom surfaces are generally in a horizontal

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*Shawnee, F72113R, Tennessee Valley Authority, Knoxville, Tennessee.

†Lime/Limestone Wet-Scrubbing Test Results at the EPA Alkali Scrubbing Test Facility, Second Progress Report, Technology Transfer, U.S. Environmental Protection Agency, Washington, D.C.

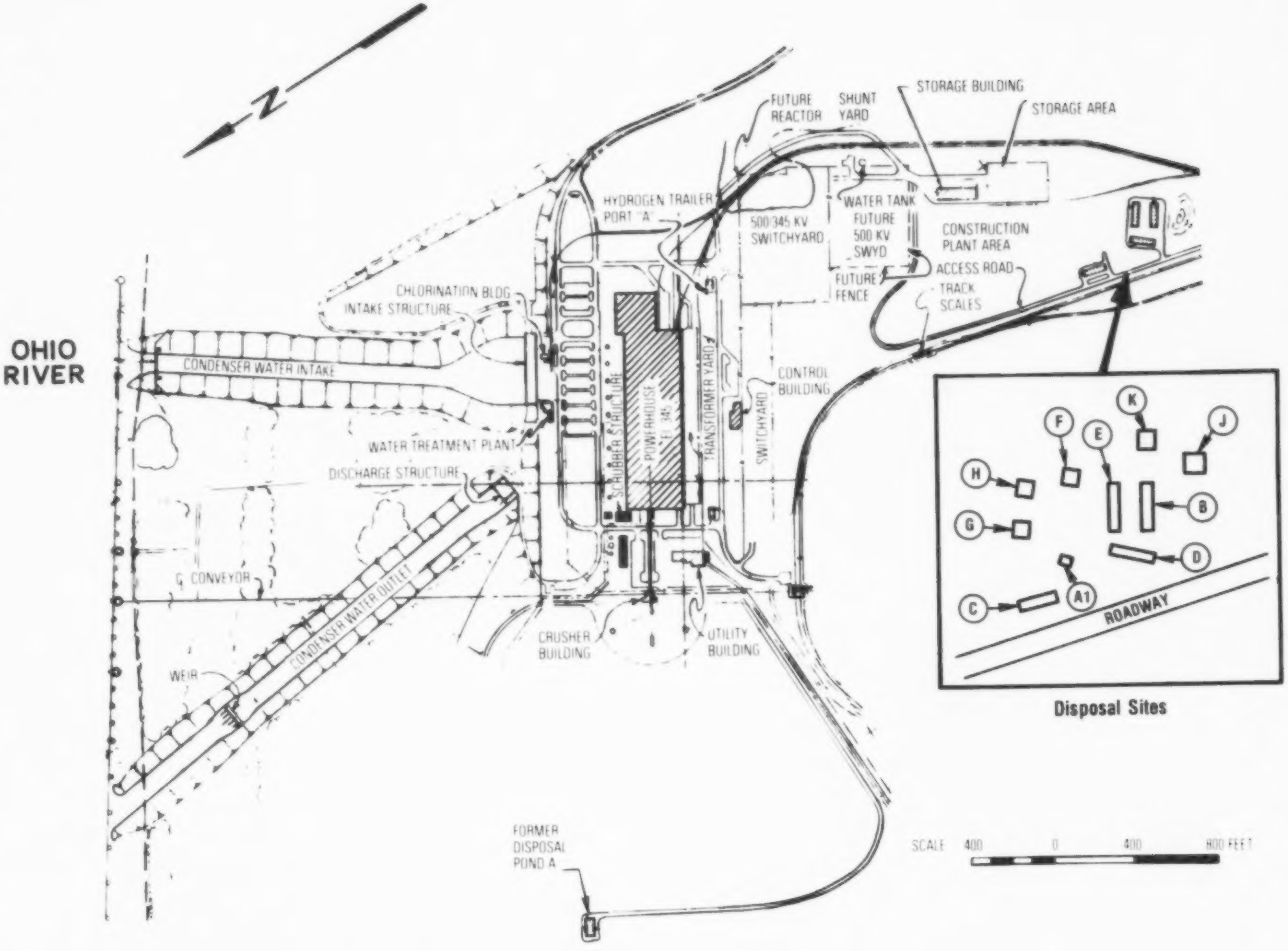

N
OHIO RIVER
CONDENSER WATER INTAKE
CHLORINATION BLDG
INTAKE STRUCTURE
WATER TREATMENT PLANT
DISCHARGE STRUCTURE
CONVEYOR
CONDENSER WATER OUTLET
WEIR
FORMER DISPOSAL POND A
CRUSHER BUILDING
UTILITY BUILDING
SCRUBBER STRUCTURE
POWERHOUSE
EL 345
TRANSFORMER YARD
SWITCHYARD
CONTROL BUILDING
HYDROGEN TRAILER PORT "A"
500/345 KV SWITCHYARD
FUTURE REACTOR
SHUNT YARD
WATER TANK
FUTURE 500 KV SWYD
FUTURE FENCE
STORAGE BUILDING
STORAGE AREA
CONSTRUCTION PLANT AREA
ACCESS ROAD
TRACK SCALES
H
G
F
E
K
J
B
D
C
A1
ROADWAY
Disposal Sites
SCALE 400 0 400 800 FEET

Figure B-1. Shawnee Steam Plant alkali scrubbing test facility waste disposal evaluation site locations and details

TABLE B-1. SHAWNEE DISPOSAL SITE DIMENSTIONS

Site	Length, ft[a]	Width, ft[a]	Side Slope	Waste Depth, ft
A1	10	10	2:3	3
B, E	140	38	2:1	3
C	133	38	2:1	3
D	147	40	2:1	3
F	40	40	2:1	4
G	40	40	2:1	4
H (lower)	40	40	2:1	4
H (upper)	40	40	--	10[c]
J[b]	70	70	--	10[c]
K[b]	40	40	--	5[c]

[a] Length and width dimensions are to the top of the berm.

[b] Sites J and K constructed at grade with 1.5-ft high berms around perimeter to control runoff.

[c] Height of stack.

plane, and the side walls are protected from erosion through the use of limestone rock.

Leachate wells have been constructed in Sites A1, B, C, D, and E; Sites F, G, and H are constructed with underdrain systems. Access to the leachate well in Site A1 was provided by constructing a walkway across the berms adjacent to the well. For each of Sites B, C, D, and E, a wooden pier was constructed at one end of the site to serve as a support for the leachate well and to provide a sampling station of obtaining leachate well water. For Sites F, G, and H, access was provided to the underdrain collection tank and pump, for inspection and maintenance purposes, through the use of metal steps placed in the concrete liner of the collection pit. The upper portion of Site H and Sites J and K were constructed such that all rainwater applied would run off to one corner of the site. At this point a runoff collection device (which consisted of a 30- or 50-gal drum with a small bucket within for water collection) was provided to allow for collection and and sampling of runoff. Additionally, lysimeters were installed in all three sites. The purpose of the lysimeters is to provide a means of sampling the water passing through the waste layer. The lysimeters perform a similar function to leachate wells. Figure B-2 shows the disposal areas in relationship to each other and the nomenclature and position of the leachate, underdrain, and ground water wells.

B.3.1 Leachate Well Construction

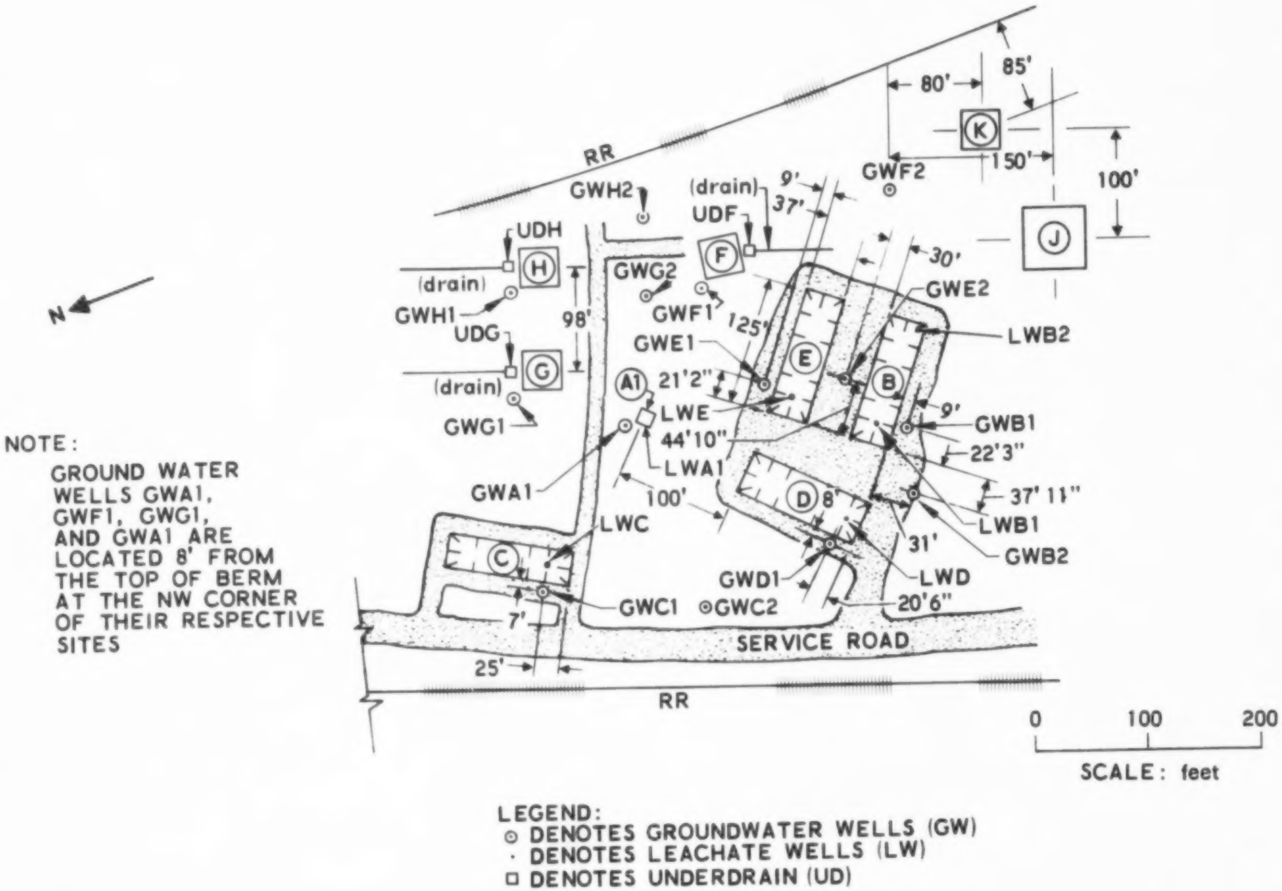
Leachate wells have been constructed on the flat bottom of Sites A1, B, C, D, and E. The purpose of these wells is to provide water samples that can be analyzed to determine the quality of the water that seeps through the waste (either untreated or treated) and enters the soil. These wells provide samples except during periods of extreme drought or subfreezing weather.

The wells have been built with 4-in.-diam plastic pipes implanted as shown in Figure B-3. This configuration is arranged to prevent solid material from blocking the entrance to the pipe. The pipe extends approximately 5 ft above the base of the site. It is anchored to the pier (except for Site A1) and is covered with a force-fit plastic cap to prevent entry of foreign matter (including rainwater) into the well. The installation is such that surface water cannot freely flow between the waste and the pipe or through the upper end. A layer of diatomaceous earth is used to filter suspended solids in the leachate.

B.3.2 Underdrain Construction

Underdrain systems have been constructed on the bottoms of Site F, G, and H. The purpose of these systems is to remove water that seeps to the site bottom, thereby enhancing waste drainage, which improves structural properties. Samples or water collected from the underdrain system are analyzed for environmental quality.

The underdrain systems are constructed with 4-in.-diam plastic pipe implanted in the disposal site bottom, as shown in Figure B-4. The collection


RR
GWH2
(drain)
UDF
9'
37'
GWF2
80'
85'
K
150'
100'
J
UDH
H
(drain)
GWH1
UDG
G
(drain)
GWG1
98'
N
GWG2
F
GWF1
125'
30'
GWE2
LWB2
GWE1
E
B
A1
21'2"
LWE
44'10"
LWA1
9'
GWB1
22'3"
GWA1
100'
D
8'
37' 11"
LWB1
GWB2
31'
LWC
C
LWD
GWD1
GWC1
GWC2
20'6"
7'
SERVICE ROAD
25'
RR
0
100
200
SCALE: feet

NOTE:
GROUND WATER WELLS GWA1, GWF1, GWG1, AND GWA1 ARE LOCATED 8' FROM THE TOP OF BERM AT THE NW CORNER OF THEIR RESPECTIVE SITES

LEGEND:
⊙ DENOTES GROUNDWATER WELLS (GW)
· DENOTES LEACHATE WELLS (LW)
□ DENOTES UNDERDRAIN (UD)

Figure B-2. Disposal site and well nomenclature

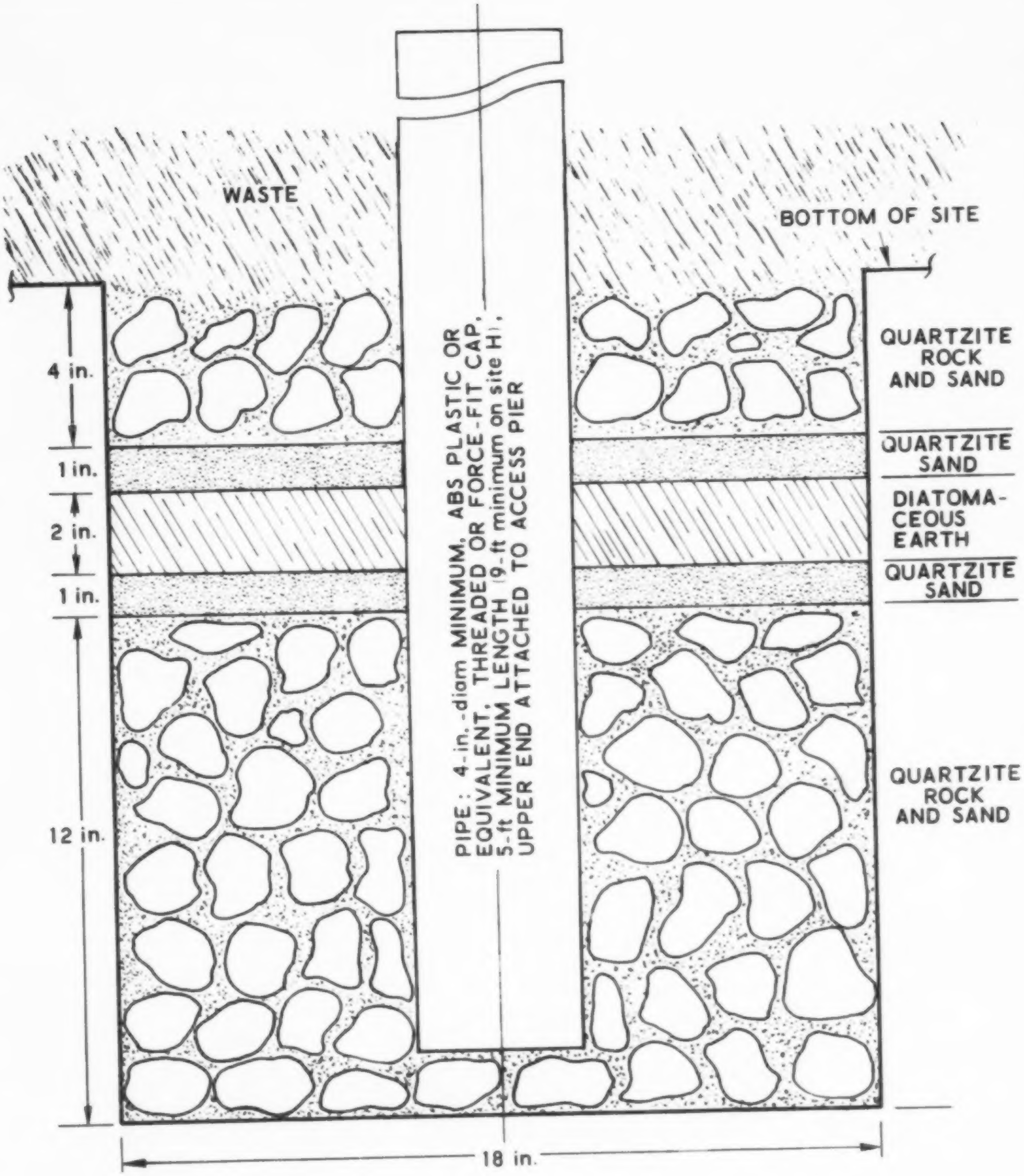

WASTE
BOTTOM OF SITE
QUARTZITE ROCK AND SAND
QUARTZITE SAND
DIATOMACEOUS EARTH
QUARTZITE SAND
QUARTZITE ROCK AND SAND
4 in.
1 in.
2 in.
1 in.
12 in.
18 in.
PIPE: 4-in.-diam MINIMUM, ABS PLASTIC OR EQUIVALENT, THREADED OR FORCE-FIT CAP, 5-ft MINIMUM LENGTH (9-ft minimum on site H), UPPER END ATTACHED TO ACCESS PIER

Figure B-3. Leachate collection well

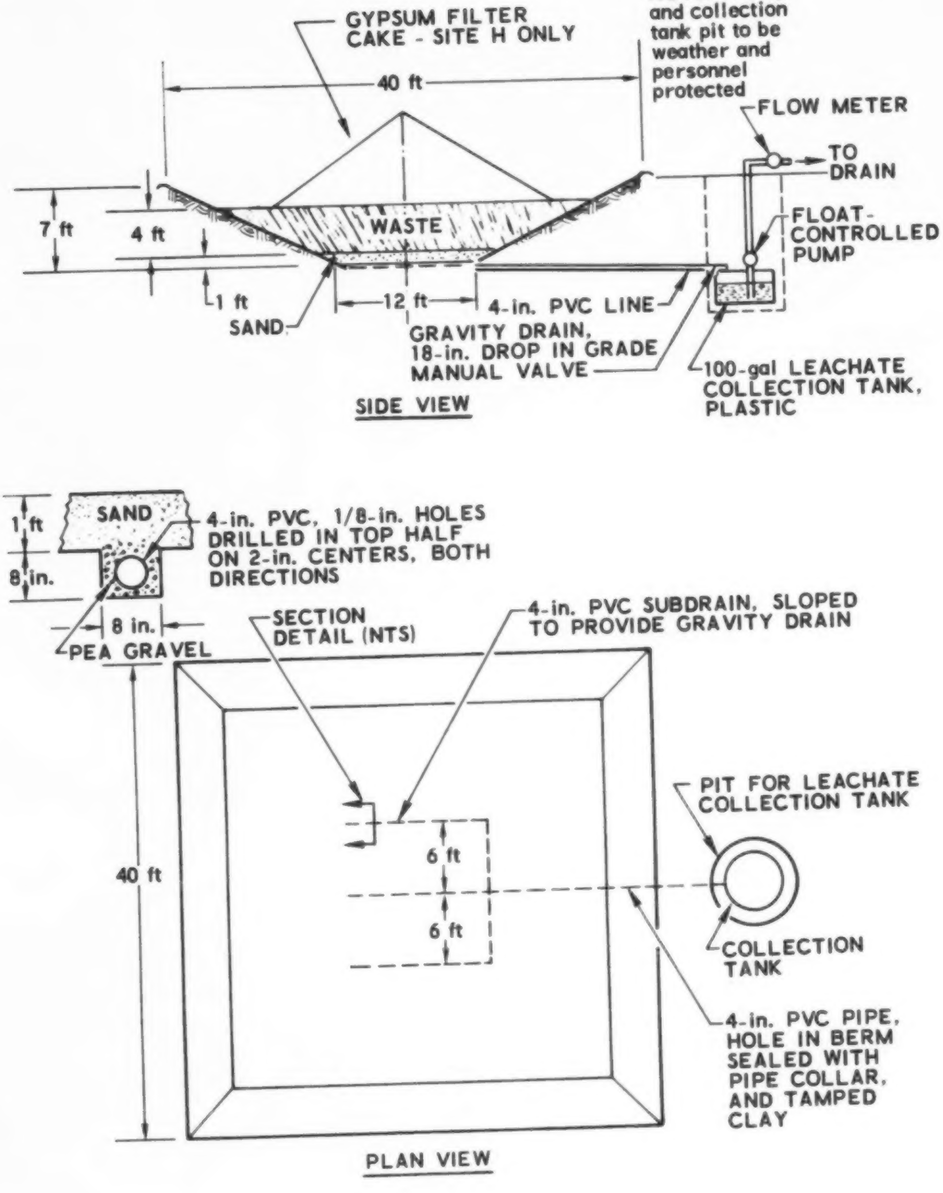

NOTE: Pump and collection tank pit to be weather and personnel protected
GYPSUM FILTER CAKE - SITE H ONLY
40 ft
FLOW METER
TO DRAIN
7 ft
4 ft
WASTE
FLOAT-CONTROLLED PUMP
1 ft
SAND
12 ft
4-in. PVC LINE
GRAVITY DRAIN, 18-in. DROP IN GRADE
MANUAL VALVE
100-gal LEACHATE COLLECTION TANK, PLASTIC
SIDE VIEW
1 ft
SAND
8 in.
4-in. PVC, 1/8-in. HOLES DRILLED IN TOP HALF ON 2-in. CENTERS, BOTH DIRECTIONS
8 in.
PEA GRAVEL
SECTION DETAIL (NTS)
4-in. PVC SUBDRAIN, SLOPED TO PROVIDE GRAVITY DRAIN
PIT FOR LEACHATE COLLECTION TANK
6 ft
40 ft
6 ft
COLLECTION TANK
4-in. PVC PIPE, HOLE IN BERM SEALED WITH PIPE COLLAR, AND TAMPED CLAY
PLAN VIEW

Figure B-4. Underdrain system installed in Sites F, G, and H pipes are drilled on their top halves with 1/8-in. holes on 2-in. centers and have been covered with pea gravel. There is a 1-ft layer of sand on top of the pea gravel; this improves the dewatering of the waste and filters out particulate matter. The collection pipes are connected to a single gravity-drained pipe, which flows to a 100-gal plastic tank. Water is pumped from the collection tank to the surface by a float-operated pump. The water pumped from each site is metered so that the quantity of water drained can be directly compared to the rainfall measured at the site.

B.3.3 Ground Water Well Construction

A ground water well has been constructed approximately 100 ft from each site in the ground water upstream direction for background water quality measurements. The wells are constructed of either 4- or 6-in.-diam plastic pipe, anchored in concrete, packed with clay to prevent seepage down the well shaft, and installed to extend from 3 to 5 ft below the water table. The pipe is covered with a force-fit plastic cover.

Ground water wells have been constructed on the berms of Sites B, C, D, and E to measure the quality of ground water at those locations. These wells are located downstream from the disposal sites relative to the direction of ground water flow. The more recently constructed sites F, G, and H do not have ground water wells installed on the site berms. On the basis of experience with the other sites, a single well installed in the downstream direction should be adequate to monitor these disposal sites.

B.4 WEATHER DATA STATION

A weather station, containing both recording and nonrecording instrumentation, has been installed for the purpose of determining weather conditions at the sites that may effect the disposal evaluations. Initially, this station was located in the vicinity of the original site of Site A; however, since February 1975, it has been located in the vicinity of Site D, which is somewhat central to the total site evaluation area.

Measurements made at this station include the following:

a. Air and water temperature

b. Precipitation

c. Evaporation

d. Wind movement

e. Relative humidity

APPENDIX C

OPERATIONS AND SCHEDULES

The first five disposal sites (A through E) were constructed in 1974, and disposal evaluation activities began when the first of these, Site A, was filled between September 24 and October 3, 1974. The filling of four additional sites (B through E) was completed by mid-April 1975. The construction of Sites F, G, and H was completed in September 1976, and these sites were subsequently filled during the following 12 months, i.e., G in October 1976, F in February 1977, and H in September 1977. The final two sites, J and K, were completed in December 1978 and March 1979, respectively. The source material and other characteristics including present conditions for all the sites are summarized in Table 1 of this report. Detailed descriptions of the filling of sites A through H have been published in other reports (Refs. C-1, through C-3). Sites J and K were filled during this final reporting period and a description of those operations follows.

C.1 DISPOSAL SITE FILLING AND CHEMICAL TREATMENT

The two sites filled during this final reporting period represent a continuing investigation of FGD waste disposal materials and methods. Disposal materials previously included untreated lime and limestone wastes in indigenous clay-lined sites; lime and limestone wastes chemically treated and evaluated under conditions representing either a low spot in a landfill or disposal behind a dam; and untreated, dewatered ash-free lime waste mixed with fly ash and placed in an underdrained pond in alternate layers with additional fly ash. There has been increasing interest in oxidized sulfite (gypsum) scrubbing processes and, thus, an interest in evaluating the pollution potential of gypsum waste. While the fill material for Site H was selected from a gypsum ash-free test run with both clarifier underflow and filter cake used, Sites J and K were taken from filter cake with ash. Site J represents a case where adipic acid was added to the scrubber liquor to improve scrubber efficiency, and Site K represents a case where the unreacted limestone content is relatively high.

C.1.1 Site J

Site J was prepared by clearing a 70 ft × 70 ft square area and constructing a 1.5-ft berm. Construction on Site J began in August of 1978, and filling was done from October 10, 1978 to December 31, 1978 with a gypsum filter cake. The source of this waste was a venturi spray tower (VST) scrubber run where adipic acid was used as an additive and limestone was used as the absorbent. The filter cake contained approximately 80% solids when it left the rotary vacuum filter at 0.75 yd/hr and was placed in dump trucks for delivery to the disposal site. A total of 500 yd of material was placed at Site J. A bulldozer was used to shape the material to a generally conical shape. Provisions were taken to collect runoff samples from the pile in order to conduct chemical analyses by means of a 55-gal drum buried in the ground with a 5-gal bucket suspended inside to catch runoff as it collects in the large drum. The large drum has holes cut in it to allow water to percolate into the ground after the sample is collected. The holes also prevent the drum from being forced out of the ground by the buoyant action of the soil on the drum.

C.1.2 Site K

Site K was prepared in a similar manner as Site J. However, in this case the clearing was 40 ft × 40 ft. The gypsum material was also similar in that its source was a VST with limestone absorbent, but in this case no adipic acid was added and there was 25 wt% untreated limestone remaining in the filter cake. A total of 150 yd of material was placed from March 3, 1979 to March 29, 1979.

C.2 SCHEDULES

A series of sampling schedules were regularly maintained for the project, including an overall schedule and individual schedules for each pond. The final revision to these schedules are given in Reference C-4.

C.3 SAMPLING AND ANALYSIS

An essential part of the evaluation project was the sampling and analysis of input waste materials, pond waters, ground waters, and soil in the disposal site bottoms. The supernate, runoff, leachate or underdrain, and ground waters were sampled and analyzed bimonthly to determine the concentration of calcium, sulfate, sulfite, chloride, TDS, and selected trace elements and to measure pH. A matrix of the water sample taken is identified in Table C-1. The ground water was sampled from two locations for each site, i.e., from a well near the berm on the ground water "downstream" side of the site and from a point "upstream" of the site at a distance approximately 100 ft away. Once each year the leachate or underdrain is analyzed for a full chemical characterization in accordance with Table C-2. Methods used to determine these characteristics are given in Appendix E.

Beginning in 1975, core samples were taken regularly of the soil in the disposal site bottoms and of the waste and soil interface for the three sites containing chemically treated wastes. In 1978, the coring operation was expanded to also include the untreated and gypsum sites. The soil samples were analyzed for moisture content, grain size, Atterberg limits dry density, coefficient of permeability, and concentration of major constituents. The chemically treated and untreated waste core samples were analyzed for physical properties, such as permeability and unconfined compressive strength, and chemical characteristics. An Instron unit, including a calibrated load cell,

TABLE C-1. IDENTIFICATION OF WATER SAMPLE TYPES

Site	Runoff	Supernate	Leachate/Underdrain Well 1	Leachate/Underdrain Well 2	Lysimeter	Ground Water Well 1	Ground Water Well 2
A1	--	PSA1	LWA1	--	--	GWA1	--
B	--	PSB	LWB1[a]	LWB2	--	GWB1	GWB2
C	PRC	PSC	LWC	--	--	GWC1	GWC2
D	--	PSD	LWD	--	--	GWD1	--
E	--	PSE	LWE	--	--	GWE1	GWE2
F	--	--	UDF	--	--	GWF1	GWF2
G	--	--	UDG	--	--	GWG1	GWG2
H	PRH	--	UDH	--	LSH	GWH1	GWH2
J	PRJ	--	--	--	LSJ	--	--
K	PRK	--	--	--	LSK	--	--

[a] Originally LWB.

TABLE C-2. CHEMICAL CHARACTERIZATION PARAMETER LIST[a]

Aluminum	Selenium
Antimony	Silicon
Arsenic	Silver
Barium	Sodium
Boron	Tin
Cadmium	Vanadium
Calcium	Zinc
Total Chromium	Total Carbonate
Cobalt	Chloride
Copper	Fluoride
Iron	Sulfate
Lead	Phosphate
Magnesium	Total Nitrogen
Manganese	Chemical Oxygen Demand
Mercury	TDS
Molybdenum	Total Alkalinity
Nickel	Conductance, millimhos/cm
Potassium	pH

[a] Concentration: mg/l unless otherwise indicated.

was used for determining unconfined compressive strength. The results of the waste and soil analyses are presented in the Technical Discussion (Section V) of this report. Core samples were not taken from Pond A during its operation, primarily because of the proximity of the ground water to the pond bottom at that location, nor from Site A1, because of the restricted size (10 ft × 10 ft) of that pond.

C.4 DISPOSAL SITE CLOSURE (RETIREMENT)

As another step in the evaluation project, two operational sites were initially selected for closure and further evaluation in that mode. The two sites selected were Site E (chemically treated, Chemfix process) and Site F (untreated, with underdrain). A third site, (Site G (untreated with underdrainage) was later covered and added to the evaluation because of increased water seepage in the two previously covered sites. The purposes of the closure activity were to (a) monitor the quantity and evaluate the characteristics of any seepage from the sites under conditions simulating the completion of the waste disposal process, (b) evaluate the structural stability of the soil cover, and (c) observe any effect of waste uptake in the cover vegetation. Closure was implemented by covering the sites with clay material indigenous to the area, compacting the cover layer, sloping, and planting it with vegetation so that the cover would shed rainfall without eroding. The leachate well or underdrain system was used for sampling and analysis of leachate and underdrain water. A complete description of the considerations and procedures used in covering these sites can be found in Reference C-3.

C.4.1 Tree Planting

As a separate EPA/TVA project not reported herein, two varieties of trees were planted on covered Sites E and F. The types of trees chosen for this purpose have rapidly developing root systems so that the roots were expected to reach the waste top-soil interface within one year. To further facilitate this, the crown of both soil caps were cut down to approximately one foot. In addition to the trees planted on the cover of the two sites, additional "control" trees were planted in an area adjacent to the sites, using soil indigenous to the area. Planting was completed in the spring of 1979.

C.5 RUNOFF CONFIGURATION OF SITE C

The configuration of Site C was changed to a runoff mode in March 1979. This was accomplished by cutting a ditch through the northernmost berm, which led away from the site. The runoff mode exposes the treated waste to weathering conditions and allows an estimate of the seepage potential through this material when water is not allowed to stand. A runoff collection device similar to that for Sites J and K was installed near the low end of the site to collect rainwater that had passed over the waste in the site. Bi-monthly analyses were conducted on the runoff water collected.

C.6 REFERENCES

C-1. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation: Initial Report, EPA-600/2-76-070, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (March 1976).

C-2. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation: Second Annual Report, EPA-600/7-77-052, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (February 1978).

C-3. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation: Third Annual Report, EPA-600/7-80-011, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (January 1980).

C-4. Test Plan, EPA Shawnee Sulfur Scrubbing Waste Disposal Field Evaluation, Revision III, ATR-80(7660-05)-1, The Aerospace Corporation, El Segundo, California (1 January 1980).

APPENDIX D

WATER ANALYSIS DATA

The following is a computer-generated list of the water analyses conducted by The Aerospace Corporation and the Tennessee Valley Authority (TVA). The Aerospace Corporation performed periodic duplicate analyses of the water samples and the analyses of the trace elements. The complete chemical characterization analyses and the concentration versus time plots of the runoff analyses given in Section 5.2 were based on the analyses data from both The Aerospace Corporation and TVA. The data given in all other water analyses are based on TVA values.

POND A SUPERNATE

WELL DESIG	PSA	PSA	PSA	PSA	PSA	PSA	PSA	PSA
DATE	741022.0000	741209.0000	750212.0000	750428.0000	750707.0000	750901.0000	751107.0000	760106.0000
REC NO.	100.0000	120.0000	140.0000	160.0000	180.0000	200.0000	220.0000	240.0000
PH	8.1000	8.2000	8.5000	8.0000	0.0000	8.2000	8.4000	7.7000
ALKALINITY	100.0000	60.0000	49.0000	43.0000	0.0000	34.0000	40.0000	36.0000
CHLORIDE	2000.0000	980.0000	630.0000	250.0000	300.0000	440.0000	330.0000	300.0000
COD	0.0000	60.0000	24.0000	14.0000	20.0000	29.0000	38.0000	27.0000
COND	8000.0000	4600.0000	3200.0000	1800.0000	2500.0000	3600.0000	3700.0000	1800.0000
TDS	7100.0000	4300.0000	2800.0000	1600.0000	2300.0000	3600.0000	3500.0000	1900.0000
TSS	18.0000	27.0000	6.0000	7.0000	14.0000	6.0000	20.0000	31.0000
SULFATE	1400.0000	1100.0000	1100.0000	570.0000	810.0000	1900.0000	1300.0000	540.0000
ARSENIC	.0300	.0150	< .0050	< .0050	.0060	.1200	.0190	< .0050
BORON	16.0000	2.2000	8.8000	0.0000	5.3000	8.3000	14.0000	0.0000
CALCIUM	2000.0000	1100.0000	880.0000	480.0000	640.0000	1200.0000	1200.0000	670.0000
LEAD	< .0100	< .0100	< .0100	.0160	< .0100	.0200	< .0100	.0230
MAGNESIUM	140.0000	71.0000	48.0000	20.0000	21.0000	26.0000	34.0000	19.0000
MERCURY	.0005	< .0002	.0003	< .0002	.0017	< .0002	< .0002	.0014
SELENIUM	< .0020	< .0020	< .0020	< .0020	.0020	< .0020	< .0010	< .0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	0.0000	0.0000	16.0000	23.0000	27.0000	20.0000
TOTAL ELEM	5556.0425	3253.2272	2666.8173	1320.0232	1792.3197	3597.4422	2905.0302	1549.0314

POND A SUPERNATE

WELL DESIG	PSA	PSA	PSA	PSA	PSA	PSA	PSA	PSA
DATE	760301.0000	760706.0000	770302.0000	770505.0000	771216.0000	780316.0000	780511.0000	780821.0000
REC NO.	260.0000	280.0000	300.0000	320.0000	340.0000	360.0000	380.0000	400.0000
PH	7.8000	7.4000	7.5000	6.7000	6.8000	7.3000	7.3000	7.7000
ALKALINITY	26.0000	84.0000	55.0000	37.0000	43.0000	78.0000	42.0000	88.0000
CHLORIDE	130.0000	42.0000	74.0000	18.0000	5.0000	4.0000	5.0000	12.0000
COD	58.0000	32.0000	22.0000	10.0000	24.0000	18.0000	12.0000	21.0000
COND	1500.0000	930.0000	1400.0000	800.0000	450.0000	460.0000	900.0000	1000.0000
TDS	1500.0000	1800.0000	1500.0000	710.0000	300.0000	300.0000	720.0000	900.0000
TSS	16.0000	7.0000	3.0000	1.0000	10.0000	6.0000	3.0000	6.0000
SULFATE	690.0000	320.0000	820.0000	430.0000	160.0000	86.0000	440.0000	540.0000
ARSENIC	< .0100	.0150	.0070	.0060	< .0020	< .0020	.0040	.0080
BORON	3.8000	2.0000	3.6000	1.7000	.2200	.1400	.3800	2.7000
CALCIUM	540.0000	240.0000	390.0000	170.0000	98.0000	64.0000	200.0000	260.0000
LEAD	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100
MAGNESIUM	17.0000	12.0000	17.0000	7.2000	7.6000	4.3000	8.4000	8.4000
MERCURY	< .0002	< .0002	< .0002	< .0020	< .0002	< .0002	< .0002	< .0002
SELENIUM	< .0040	.0030	.0080	< .0020	< .0020	< .0020	.0020	.0010
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	15.0000	8.9000	8.6000	2.6000	3.4000	1.8000	1.9000	1.8000
TOTAL ELEM	1395.8242	624.9282	1313.2252	629.5200	274.2342	160.2542	655.6962	824.9192

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POND A SUPERNATE

WELL DESIG           PSA          PSA          PSA          PSA          PSA          PSA          PSA
DATE         781207.0000  790309.0000  790522.0000  790907.0000  791113.0000  800111.0000  800317.0000
REC NO.         420.0000     440.0000     460.0000     480.0000     500.0000     520.0000   17220.0000
PH                7.3000       7.2000       7.2000       7.3000       7.4000       7.2000       7.3000
ALKALINITY       56.0000      74.0000     120.0000     120.0000      68.0000      50.0000      36.0000
CHLORIDE          2.0000       4.0000       6.0000       5.0000       2.0000       3.0000       2.0000
COD              18.0000      16.0000      31.0000      23.0000      15.0000      18.0000      18.0000
COND            260.0000     360.0000     510.0000     470.0000     220.0000     280.0000     150.0000
TDS              70.0000     200.0000     380.0000     400.0000     150.0000     210.0000     430.0000
TSS              28.0000       4.0000       5.0000       5.0000       3.0000      28.0000      45.0000
SULFATE          24.0000     100.0000     170.0000     140.0000      38.0000      72.0000      31.0000
ARSENIC            .0020        .0040        .0060        .0170        .0050        .0050        .0300
BORON              .1100       6.0000        .3100        .8500        .0200  <     .0100        .0800
CALCIUM          36.0000     100.0000     130.0000     100.0000      74.0000      43.0000      23.0000
LEAD       <       .0100  <     .0100        .0370  <     .0100  <     .0100  <     .0100        .0110
MAGNESIUM         3.0000       2.5000       5.1000       5.6000       3.4000       3.8000       2.0000
MERCURY    <       .0002  <     .0002  <     .0002  <     .0002  <     .0002  <     .0002  <     .0002
SELENIUM   <       .0010  <     .0010        .0020        .0040  <     .0010  <     .0010  <     .0010
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            3.1000       2.7000       1.1000       1.1000       2.3000       1.2000        .2000
TOTAL ELEM       68.2232     215.2152     312.5552     252.5812     119.7362     123.0262      58.3222
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POND A SUPERNATE    --- AEROSPACE ---

WELL DESIG           PSA          PSA          PSA          PSA          PSA          PSA          PSA          PSA
DATE         741028.0000  750428.0000  751103.0000  760415.0000  770505.0000  780309.0000  780316.0000  790314.0000
REC NO.         540.0000     560.0000     580.0000     600.0000     620.0000     640.0000     660.0000     680.0000
PH                7.7100       7.6800       7.1300       7.0800       6.6900       7.9200       7.8200       7.1000
ALKALINITY       59.0000      43.0000      41.0000      47.0000      34.0000      61.0000      54.0000      84.0000
CHLORIDE       1600.0000     390.0000     710.0000     350.0000      96.0000       4.5000       4.5000       5.0000
COD               0.0000      50.0000      65.0000       0.0000       0.0000       0.0000       0.0000       0.0000
COND           7800.0000    1800.0000    3440.0000    2080.0000     780.0000     282.0000     317.0000     366.0000
TDS            5850.0000    1540.0000    3870.0000    2080.0000     656.0000     190.0000     258.0000     284.0000
TSS              10.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SULFATE        1500.0000     650.0000    1675.0000     750.0000     427.0000      82.0000      95.0000     130.0000
ARSENIC           0.0000        .0050        .0040  <     .0010        .0040        .0070       0.0000        .0300
BORON            22.8000       1.9000       8.8000       6.3000        .9000  <     .5000       1.4000        .6000
CALCIUM        1480.0000     540.0000     760.0000     455.0000     190.0000      46.0000      47.0000     100.0000
LEAD               .0930        .1000  <     .0100  <     .0100        .0850        .1200       0.0000  <     .0900
MAGNESIUM          .6000       4.6000      33.0000      18.0000       6.2000       6.1000       6.2000       8.0000
MERCURY           0.0000        .0002        .0003        .0013  <     .0001        .0005       0.0000        .0014
SELENIUM          0.0000        .0070        .0060        .0310  <     .0010        .0004       0.0000        .0050
SULFITE           1.3000        .2000  <     .1000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000       0.0000      30.0000      18.0000       3.7000      82.0000      95.0000       1.5000
TOTAL ELEM     4604.7930    1586.8122    3216.9203    1597.3433     723.8901     221.2279     249.1000     245.2264
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POND A SUPERNATE    --- AEROSPACE ---


WELL DESIG         PSA
DATE        791107.0000
REC NO.        700.0000
PH               6.8200
ALKALINITY      63.4000
CHLORIDE         1.0000
COD              0.0000
COND           200.0000
TDS            148.0000
TSS              0.0000
SULFATE         38.0000
ARSENIC           .0080
BORON        <    .5000
CALCIUM        265.0000
LEAD              .0900
MAGNESIUM        3.8000
MERCURY           .0001
SELENIUM          .0080
SULFITE          0.0000
SODIUM           1.2000
TOTAL ELEM     309.6061
```

POND A LEACHATE

WELL DESIG	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1
DATE	741015.0000	741209.0000	750211.0000	750428.0000	750707.0000	750901.0000	751103.0000	760106.0000
REC NO.	720.0000	740.0000	760.0000	780.0000	800.0000	820.0000	840.0000	860.0000
PH	7.0000	6.8000	7.6000	7.6000	7.5000	6.8000	7.4000	8.5000
ALKALINITY	410.0000	310.0000	150.0000	61.0000	62.0000	260.0000	230.0000	110.0000
CHLORIDE	36.0000	1800.0000	2900.0000	3300.0000	3500.0000	3300.0000	3000.0000	2200.0000
COD	0.0000	90.0000	100.0000	150.0000	1400.0000	170.0000	58.0000	180.0000
COND	1200.0000	6300.0000	9500.0000	9800.0000	10000.0000	10000.0000	11000.0000	9200.0000
TDS	830.0000	5400.0000	6600.0000	7700.0000	8100.0000	7800.0000	7600.0000	6000.0000
TSS	150.0000	170.0000	0.0000	31.0000	100.0000	330.0000	40.0000	180.0000
SULFATE	230.0000	790.0000	1100.0000	1000.0000	980.0000	1300.0000	940.0000	1000.0000
ARSENIC	< .0050	< .0050	< .0050	< .0050	.0200	.0060	.0750	.1200
BORON	.3800	2.2000	28.0000	31.0000	42.0000	48.0000	36.0000	0.0000
CALCIUM	160.0000	1200.0000	2100.0000	1600.0000	2300.0000	3000.0000	2700.0000	2500.0000
LEAD	< .0100	< .0100	.0480	.0320	.0620	.0150	.1200	.1100
MAGNESIUM	44.0000	120.0000	98.0000	72.0000	82.0000	120.0000	81.0000	74.0000
MERCURY	.0019	.0012	.0010	.0018	.0067	.0009	.0009	.0013
SELENIUM	< .0020	< .0020	< .0020	.0120	.0130	.0040	< .0010	.0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	0.0000	0.0000	0.0000	96.0000	120.0000	71.0000
TOTAL ELEM	470.3989	3912.2182	6226.0560	6003.0508	6904.1017	7864.0279	6877.1969	5845.2333

POND A LEACHATE

WELL DESIG	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1
DATE	760301.0000	760706.0000	761109.0000	770215.0000	770302.0000	770505.0000	770707.0000	770926.0000
REC NO.	880.0000	900.0000	920.0000	940.0000	960.0000	980.0000	1000.0000	1020.0000
PH	8.3000	7.4000	7.2000	7.4000	7.4000	7.2000	7.2000	7.3000
ALKALINITY	89.0000	110.0000	58.0000	62.0000	55.0000	41.0000	55.0000	54.0000
CHLORIDE	1800.0000	1200.0000	810.0000	610.0000	860.0000	740.0000	410.0000	320.0000
COD	48.0000	46.0000	47.0000	4.0000	27.0000	23.0000	24.0000	23.0000
COND	7600.0000	3800.0000	3200.0000	3200.0000	3300.0000	3100.0000	2800.0000	3400.0000
TDS	5400.0000	4100.0000	4000.0000	3500.0000	4000.0000	3700.0000	3400.0000	3200.0000
TSS	21.0000	93.0000	910.0000	140.0000	89.0000	59.0000	37.0000	120.0000
SULFATE	1200.0000	1100.0000	1420.0000	1350.0000	1200.0000	1400.0000	1400.0000	1500.0000
ARSENIC	.0600	< .0100	.0120	< .0020	< .0020	.0050	< .0040	< .0040
BORON	46.0000	21.0000	21.0000	53.0000	27.0000	27.0000	20.0000	34.0000
CALCIUM	1500.0000	850.0000	910.0000	730.0000	660.0000	760.0000	770.0000	510.0000
LEAD	.3200	.0190	.0380	.0200	.0130	.0160	.0100	.0140
MAGNESIUM	82.0000	130.0000	91.0000	67.0000	64.0000	62.0000	47.0000	40.0000
MERCURY	.0005	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002
SELENIUM	.0060	.0030	.0110	.0080	.0040	.0060	.0110	.0180
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	64.0000	140.0000	81.0000	62.0000	61.0000	44.0000	40.0000	34.0000
TOTAL ELEM	4692.3865	3441.0322	3333.0612	2872.0302	2872.0192	3033.0272	2687.0252	2438.0362

POND A LEACHATE

WELL DESIG	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1
DATE	771108.0000	771216.0000	780316.0000	780511.0000	780821.0000	781206.0000	790122.0000	790525.0000
REC NO.	1040.0000	1060.0000	1080.0000	1100.0000	1120.0000	1140.0000	1160.0000	1180.0000
PH	0.0000	7.4000	8.2000	7.4000	7.5000	7.3000	7.1000	7.2000
ALKALINITY	0.0000	41.0000	32.0000	34.0000	63.0000	5.9000	38.0000	51.0000
CHLORIDE	0.0000	220.0000	80.0000	120.0000	16.0000	20.0000	24.0000	5.0000
COD	18.0000	64.0000	13.0000	21.0000	25.0000	46.0000	0.0000	25.0000
COND	0.0000	2800.0000	2400.0000	2500.0000	2600.0000	2500.0000	2500.0000	2300.0000
TDS	0.0000	2700.0000	2300.0000	2400.0000	2500.0000	2300.0000	2300.0000	2300.0000
TSS	0.0000	460.0000	7.0000	23.0000	130.0000	460.0000	650.0000	42.0000
SULFATE	0.0000	1400.0000	1312.0000	1300.0000	1600.0000	1500.0000	1400.0000	1400.0000
ARSENIC	< .0040	< .0020	.0020	.0060	.0050	.0200	.0240	.0230
BORON	36.0000	22.0000	12.5000	5.0000	30.0000	4.8000	6.4000	5.1000
CALCIUM	110.0000	770.0000	510.0000	650.0000	780.0000	640.0000	590.0000	750.0000
LEAD	.0360	< .0100	< .0100	.0180	.0210	.0440	.0350	.0310
MAGNESIUM	45.0000	35.0000	17.0000	21.0000	24.0000	20.0000	24.0000	14.0000
MERCURY	< .0002	.0004	< .0002	.0023	< .0002	< .0002	< .0002	< .0002
SELENIUM	.0240	.0100	.0020	.0020	.0480	.0090	.0120	.0040
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	34.0000	22.0000	45.0000	11.0000	15.0000	6.4000	6.3000	4.1000
TOTAL ELEM	225.0642	2469.0224	1976.5142	2107.0283	2465.0742	2191.2732	2050.7712	2178.2582

POND A LEACHATE

WELL DESIG	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1	LWA1
DATE	790716.0000	790912.0000	791113.0000	800114.0000	800311.0000	800515.0000	800701.0000
REC NO.	1200.0000	1220.0000	1240.0000	1260.0000	17140.0000	17660.0000	17900.0000
PH	6.6000	7.0000	6.9000	7.4000	7.0000	7.0000	7.3000
ALKALINITY	30.0000	70.0000	64.0000	46.0000	48.0000	40.0000	79.0000
CHLORIDE	6.0000	2.0000	6.0000	3.0000	3.0000	5.0000	5.0000
COD	27.0000	12.0000	16.0000	6.0000	35.0000	40.0000	16.0000
COND	2300.0000	2300.0000	2200.0000	2200.0000	2300.0000	2400.0000	2500.0000
TDS	2300.0000	2300.0000	2300.0000	2200.0000	2300.0000	2200.0000	2400.0000
TSS	160.0000	3300.0000	14.0000	38.0000	78.0000	1600.0000	70.0000
SULFATE	1400.0000	1700.0000	1500.0000	1400.0000	1400.0000	1400.0000	1500.0000
ARSENIC	.0100	.0240	.0160	.0350	.0440	.0320	.0800
BORON	.4800	12.0000	6.5000	.9300	.0900	2.1200	4.1000
CALCIUM	690.0000	670.0000	950.0000	640.0000	660.0000	720.0000	570.0000
LEAD	< .0100	< .0100	< .0100	< .0100	.0150	.0110	.0070
MAGNESIUM	7.8000	30.0000	30.0000	9.0000	8.6000	9.8000	15.0000
MERCURY	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002
SELENIUM	.0020	.0290	.0380	.0030	.0040	.0030	.0820
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	3.5000	6.8000	4.2000	1.9000	1.5000	1.6000	3.3000
TOTAL ELEM	2107.8022	2420.8632	2496.7642	2054.8782	2073.2532	2138.5662	2097.5692

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POND A LEACHATE      --- AEROSPACE ---

WELL DESIG         LWA1         LWA1         LWA1         LWA1         LWA1         LWA1         LWA1         LWA1
DATE        741014.0000  750428.0000  751103.0000  760121.0000  760415.0000  761109.0000  770302.0000  770505.0000
REC NO.       1280.0000    1300.0000    1320.0000    1340.0000    1360.0000    1380.0000    1400.0000    1420.0000
PH               7.8300       7.7100       7.2600       8.1600       7.5900       7.4000       7.4900       6.9500
ALKALINITY      49.0000      67.0000     177.0000      68.0000      60.0000      49.6000      52.0000      38.0000
CHLORIDE       840.0000    2100.0000    3400.0000    2300.0000    1500.0000     710.0000     770.0000     780.0000
COD            110.0000       0.0000     200.0000     150.0000       0.0000       0.0000       0.0000       0.0000
COND          3300.0000    9800.0000    9090.0000    6250.0000    5000.0000    4080.0000    4080.0000    3770.0000
TDS           2460.0000    7292.0000    7560.0000    5860.0000    4340.0000    3596.0000    3362.0000    3138.0000
TSS            870.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SULFATE        700.0000    1425.0000    1250.0000    1300.0000    1200.0000    1420.0000    1350.0000    1300.0000
ARSENIC          0.0000        .0050        .0040        .0590  <     .0010        .0020        .0010  <     .0010
BORON           10.2000      25.0000      47.0000      45.0000      40.0000      38.0000      32.0000      25.0000
CALCIUM        465.0000    2040.0000    2080.0000    1400.0000    1000.0000     930.0000     920.0000     860.0000
LEAD              .0270        .4400       0.0000  <     .0100        .0100        .0400        .0200        .2800
MAGNESIUM       49.3000      14.8000     129.0000      90.0000      53.0000      81.0000      68.0000      50.0000
MERCURY          0.0000        .0003        .0003  <     .0001        .0009  <     .0001  <     .0001  <     .0001
SELENIUM         0.0000        .0080        .0080        .0140        .0330        .0040  <     .0006  <     .0006
SULFITE          8.6000       0.0000        .4000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM           0.0000       0.0000      12.5000      66.0000      50.0000      82.0000      60.0000      48.0000
TOTAL ELEM    2073.1270    5605.2533    6918.9123    5201.0831    3843.0449    3261.0461    3200.0217    3063.2817
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POND A LEACHATE      --- AEROSPACE ---

WELL DESIG         LWA1         LWA1         LWA1
DATE        780309.0000  780316.0000  791113.0000
REC NO.       1440.0000    1460.0000    1480.0000
PH               7.3000       7.4500       7.2100
ALKALINITY      24.8000      25.0000      61.6000
CHLORIDE       195.0000     110.0000     200.0000
COD              0.0000       0.0000       0.0000
COND          2110.0000    2140.0000    2100.0000
TDS           2166.0000    2352.0000    2304.0000
TSS              0.0000       0.0000       0.0000
SULFATE       1312.0000    1375.0000    1500.0000
ARSENIC           .0370       0.0000        .0100
BORON           12.5000      11.6000       6.0000
CALCIUM        470.0000     490.0000     395.0000
LEAD              .2300       0.0000        .0600
MAGNESIUM       24.0000      24.0000      50.4000
MERCURY           .0011       0.0000        .0006
SELENIUM          .0003       0.0000        .0070
SULFITE          0.0000       0.0000       0.0000
SODIUM          10.0000      11.0000       5.2000
TOTAL ELEM    2023.7684    2021.6000    2156.6776
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POND A GROUND WELL 1

WELL DESIG           GWA1         GWA1         GWA1         GWA1         GWA1         GWA1         GWA1         GWA1
DATE          740709.0000  740722.0000  740729.0000  740805.0000  740903.0000  741007.0000  741028.0000  741209.0000
REC NO.         1500.0000    1520.0000    1540.0000    1560.0000    1580.0000    1600.0000    1620.0000    1640.0000
PH                 6.9000       6.9000       6.8000       6.8000       6.9000       7.2000       7.0000       6.5000
ALKALINITY       390.0000     410.0000     410.0000     430.0000     370.0000     380.0000     390.0000     440.0000
CHLORIDE    3[illegible].0000      34.0000      34.0000      36.0000      35.0000      37.0000      30.0000      45.0000
COD                0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000      16.0000
COND            1100.0000     390.0000    1100.0000       0.0000       0.0000       0.0000    1200.0000    1100.0000
TDS              730.0000     770.0000     880.0000     840.0000     790.0000     820.0000     770.0000     700.0000
TSS               10.0000      40.0000      35.0000     230.0000       0.0000      83.0000      49.0000       0.0000
SULFATE          140.0000     240.0000     240.0000     280.0000     210.0000     260.0000     180.0000     110.0000
ARSENIC      <      .0050  <      .0050  <      .0050  <      .0050  <      .0050  <      .0050  <      .0050  <      .0050
BORON               .2200        .2900        .3500        .3700       0.0000        .3200        .2500        .4800
CALCIUM          120.0000     130.0000     180.0000     190.0000     160.0000     160.0000     120.0000     110.0000
LEAD                .2400        .0580        .0950        .0680       0.0000  <      .0100  <      .0100  <      .0100
MAGNESIUM          6.8000      42.0000      47.0000      56.0000      48.0000      49.0000      41.0000      32.0000
MERCURY      <      .0002        .0010       0.0000        .0013  <      .0002  <      .0003        .0002        .0004
SELENIUM     <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020
SULFITE            0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM             0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
TOTAL ELEM       298.2672     446.3560     501.4520     562.4463     453.0072     506.3373     371.2672     297.4974
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POND A GROUND WELL 1

WELL DESIG           GWA1         GWA1         GWA1         GWA1         GWA1         GWA1         GWA1         GWA1
DATE          750211.0000  750428.0000  750707.0000  750901.0000  751103.0000  760106.0000  760301.0000  770505.0000
REC NO.         1660.0000    1680.0000    1700.0000    1720.0000    1740.0000    1760.0000    1780.0000    1800.0000
PH                 6.7000       6.9000       6.5000       6.8000       7.3000       6.5000       6.6000       6.2000
ALKALINITY       380.0000     210.0000     300.0000     280.0000     200.0000     350.0000     250.0000      42.0000
CHLORIDE          25.0000      94.0000      36.0000      41.0000      46.0000      40.0000      33.0000      38.0000
COD               66.0000      19.0000      34.0000      17.0000      27.0000       0.0000       0.0000      10.0000
COND            1000.0000     930.0000     980.0000     960.0000    1000.0000     730.0000     740.0000     380.0000
TDS              670.0000     700.0000     650.0000     690.0000     670.0000     540.0000     420.0000     250.0000
TSS                0.0000      81.0000     420.0000      21.0000      20.0000     310.0000     170.0000      24.0000
SULFATE          140.0000     150.0000     150.0000     150.0000     160.0000     130.0000     140.0000      72.0000
ARSENIC      <      .0050  <      .0050        .0050  <      .0050  <      .0050  <      .0050        .0300  <      .0020
BORON               .3600        .4900        .4600       1.3000        .3700       0.0000        .3600        .5400
CALCIUM          150.0000     160.0000     110.0000     130.0000      94.0000     120.0000      98.0000      22.0000
LEAD                .0400        .0400        .0450        .0180        .0160        .0370  <      .0100        .0170
MAGNESIUM         36.0000      36.0000      36.0000      38.0000      48.0000      32.0000      31.0000       7.3000
MERCURY             .0035        .0028        .0170        .0013        .0013        .0007        .0016  <      .0002
SELENIUM     <      .0020  <      .0020  <      .0020  <      .0020  <      .0010  <      .0020  <      .0040  <      .0020
SULFITE            0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM             0.0000       0.0000      64.0000      68.0000      68.0000      62.0000      56.0000       1.6000
TOTAL ELEM       351.4305     440.5398     396.5290     428.3263     416.3933     384.0447     358.4056     141.4612
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POND A GROUND WELL 1

WELL DESIG	GWA1	GWA1	GWA1	GWA1	GWA1	GWA1	GWA1	GWA1
DATE	771216.0000	780316.0000	780511.0000	780628.0000	780821.0000	790122.0000	790524.0000	790711.0000
REC NO.	1820.0000	1840.0000	1860.0000	1880.0000	1900.0000	1920.0000	1940.0000	1960.0000
PH	6.8000	6.5000	6.9000	7.9000	7.3000	6.6000	6.9000	7.4000
ALKALINITY	100.0000	96.0000	130.0000	230.0000	210.0000	150.0000	170.0000	180.0000
CHLORIDE	140.0000	150.0000	92.0000	73.0000	76.0000	140.0000	31.0000	31.0000
COD	46.0000	19.0000	4.0000	6.0000	9.0000	12.0000	12.0000	9.0000
COND	680.0000	740.0000	630.0000	670.0000	600.0000	800.0000	560.0000	570.0000
TDS	700.0000	450.0000	400.0000	880.0000	590.0000	400.0000	360.0000	360.0000
TSS	0.0000	52.0000	150.0000	0.0000	2200.0000	320.0000	31.0000	26.0000
SULFATE	30.0000	18.0000	27.0000	1.0000	11.0000	11.0000	31.0000	74.0000
ARSENIC	.0130	< .0020	< .0040	< .0040	.0020	.0050	.0020	.0020
BORON	.1000	2.2000	.1000	.1400	.0600	.1500	.3300	.3600
CALCIUM	78.0000	25.0000	37.0000	37.0000	20.0000	48.0000	23.0000	16.0000
LEAD	.0850	.0740	.0150	.1000	.0760	.1400	.0250	< .0100
MAGNESIUM	34.0000	7.6000	14.0000	14.0000	6.8000	20.0000	8.8000	5.4000
MERCURY	.0005	< .0002	.0005	.0012	.0002	< .0002	< .0002	.0003
SELENIUM	< .0020	< .0020	.0010	< .0010	.0020	.0030	.0050	.0010
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	84.0000	49.0000	76.0000	100.0000	100.0000	65.0000	85.0000	110.0000
TOTAL ELEM	366.2005	251.8782	246.1205	225.2462	213.9402	284.2982	179.1622	236.7733

POND A GROUND WELL 1

WELL DESIG	GWA1	GWA1	GWA1	GWA1	GWA1	GWA1
DATE	790912.0000	791108.0000	800114.0000	800314.0000	800518.0000	800702.0000
REC NO.	1980.0000	2000.0000	2020.0000	16860.0000	17380.0000	17920.0000
PH	7.5000	7.7000	7.3000	7.5000	7.5000	7.7000
ALKALINITY	200.0000	220.0000	41.0000	200.0000	150.0000	38.0000
CHLORIDE	34.0000	40.0000	45.0000	56.0000	46.0000	42.0000
COD	7.0000	11.0000	4.0000	9.0000	4.0000	4.0000
COND	570.0000	560.0000	510.0000	620.0000	560.0000	620.0000
TDS	470.0000	400.0000	350.0000	400.0000	180.0000	330.0000
TSS	830.0000	150.0000	19.0000	17.0000	3.0000	5.0000
SULFATE	100.0000	55.0000	35.0000	59.0000	52.0000	110.0000
ARSENIC	.0050	.0030	< .0020	< .0020	< .0020	< .0020
BORON	.1200	.0600	.8200	.0900	.1060	.0500
CALCIUM	15.0000	16.0000	13.0000	13.0000	19.0000	8.3000
LEAD	.0300	.0120	< .0100	.0120	.0050	.0060
MAGNESIUM	5.1000	5.9000	4.8000	5.9000	7.6000	3.6000
MERCURY	< .0002	< .0002	< .0002	< .0002	< .0002	.0002
SELENIUM	.0040	.0030	.0030	.0020	.0020	.0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	120.0000	4.2000	150.0000	120.0000	95.0000	100.0000
TOTAL ELEM	274.2592	121.1982	248.6352	254.0062	219.7152	263.9602

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POND A GROUND WELL 1--- AEROSPACE ---

WELL DESIG          GWA1        GWA1        GWA1        GWA1        GWA1        GWA1        GWA1        GWA1
DATE         740904.0000 741028.0000 750415.0000 750428.0000 751103.0000 770505.0000 780309.0000 780316.0000
REC NO.        2040.0000   2060.0000   2080.0000   2100.0000   2120.0000   2140.0000   2160.0000   2180.0000
PH                8.1800      7.9400      7.1200      6.9300      7.5000      6.7200      7.6200      8.0100
ALKALINITY      179.0000      0.0000    250.0000    286.0000    314.0000     36.0000     84.0000     80.0000
CHLORIDE         84.0000     86.0000     86.0000     86.0000    100.0000     74.0000    230.0000    260.0000
COD              40.0000      0.0000      0.0000     95.0000     40.0000      0.0000      0.0000      0.0000
COND            910.0000    860.0000    690.0000    910.0000    820.0000    340.0000    595.0000    617.0000
TDS             620.0000    588.0000    480.0000    440.0000    740.0000    240.0000    338.0000    370.0000
TSS               0.0000    130.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE           8.0000    175.0000    120.0000    250.0000    150.0000     73.0000     21.0000     14.0000
ARSENIC            .0050       .0040       .0310       .0050       .0060       .0040       .0060      0.0000
BORON              .4000       .4000      1.6000       .3000       .5000       .5000      1.2000  <    .5000
CALCIUM          40.0000     40.0000     57.0000     68.0000     72.0000     19.0000     35.0000     36.0000
LEAD               .0500       .0530       .0100       .0700  <    .0200       .1000       .1200      0.0000
MAGNESIUM        72.0000     34.2000     31.0000     33.0000     40.0000      6.0000     17.0000     18.0000
MERCURY            .0008      0.0000       .0008       .0005       .0006  <    .0001       .0012      0.0000
SELENIUM           .0040       .0020       .0130       .0150       .0080  <    .0006       .0006      0.0000
SULFITE            .4000       .1000      0.0000       .5000       .3000      0.0000      0.0000      0.0000
SODIUM            0.0000      0.0000     60.0000      0.0000     78.0000     40.0000     60.0000     60.0000
TOTAL ELEM      204.8598    335.7590    355.8548    437.8905    440.8346    212.6047    364.3298    388.5000


POND A GROUND WELL 1--- AEROSPACE ---

WELL DESIG          GWA1
DATE         791108.0000
REC NO.        2200.0000
PH                7.1700
ALKALINITY      230.0000
CHLORIDE         38.0000
COD               0.0000
COND            505.0000
TDS             348.0000
TSS               0.0000
SULFATE          11.0000
ARSENIC            .0400
BORON       <      .5000
CALCIUM          14.0000
LEAD               .0200
MAGNESIUM         6.0000
MERCURY            .0001
SELENIUM           .0080
SULFITE           0.0000
SODIUM          119.0000
TOTAL ELEM      188.5681
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POND A GROUND WELL 2

WELL DESIG          GWA2         GWA2         GWA2         GWA2         GWA2         GWA2         GWA2         GWA2
DATE         740722.0000  740729.0000  740805.0000  740903.0000  741007.0000  741022.0000  741028.0000  741209.0000
REC NO.        2220.0000    2240.0000    2260.0000    2280.0000    2300.0000    2320.0000    2340.0000    2360.0000
PH                7.3000       7.1000       7.2000       7.2000       7.3000       7.7000       7.7000       8.0000
ALKALINITY      670.0000     640.0000     590.0000     570.0000     490.0000     400.0000     480.0000     400.0000
CHLORIDE         27.0000      26.0000      26.0000      27.0000      26.0000      24.0000      22.0000      30.0000
COD               0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000      16.0000
COND           1100.0000     870.0000       0.0000       0.0000       0.0000     990.0000     970.0000     850.0000
TDS             790.0000     750.0000     720.0000     680.0000     610.0000     610.0000     580.0000     550.0000
TSS             100.0000      39.0000      31.0000       0.0000      62.0000      43.0000     110.0000      18.0000
SULFATE          22.0000      32.0000      28.0000      21.0000      42.0000      40.0000      46.0000      64.0000
ARSENIC      <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050
BORON               .1400        .1600        .1600        .1200        .1200        .1000        .1000        .2300
CALCIUM         100.0000     120.0000     120.0000     100.0000      94.0000     100.0000      63.0000      59.0000
LEAD                .0850        .0520        .0890        .0140 <      .0100 <      .0100 <      .0100 <      .0100
MAGNESIUM        65.0000      66.0000      63.0000      54.0000      51.0000      52.0000      46.0000      38.0000
MERCURY      <      .0002       0.0000        .0015 <      .0002 <      .0002        .0004 <      .0002 <      .0002
SELENIUM     <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
TOTAL ELEM      214.2322     244.2190     237.2575     202.1412     213.1372     216.1174     177.1172     191.2472
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POND A GROUND WELL 2

WELL DESIG          GWA2         GWA2         GWA2         GWA2         GWA2         GWA2         GWA2
DATE         750211.0000  750428.0000  750707.0000  750901.0000  751107.0000  760106.0000  760301.0000
REC NO.        2380.0000    2400.0000    2420.0000    2440.0000    2460.0000    2480.0000    2500.0000
PH                7.4000       7.4000       7.1000       0.0000       7.5000       7.2000       7.0000
ALKALINITY       74.0000      58.0000     100.0000       0.0000     150.0000     110.0000      86.0000
CHLORIDE         18.0000      16.0000      20.0000       0.0000      13.0000       9.0000       8.0000
COD              21.0000       8.0000      47.0000      10.0000      10.0000      11.0000       6.0000
COND            500.0000     420.0000     440.0000       0.0000     470.0000     350.0000     330.0000
TDS             330.0000     320.0000     530.0000       0.0000     350.0000     240.0000     220.0000
TSS               0.0000      89.0000   19000.0000       0.0000      12.0000      50.0000      10.0000
SULFATE         130.0000      88.0000     190.0000       0.0000      88.0000      65.0000      75.0000
ARSENIC      <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050        .0100
BORON               .2600        .3400        .3300        .8000        .3100       0.0000        .1700
CALCIUM          40.0000      32.0000     110.0000      51.0000      45.0000      38.0000      28.0000
LEAD                .0280        .0160        .2000        .0220        .0170        .0300        .0490
MAGNESIUM        18.0000      12.0000       4.2000      15.0000      26.0000      14.0000      14.0000
MERCURY             .0004        .0011        .0015        .0006 <      .0002        .0007 <      .0002
SELENIUM     <      .0020 <      .0020 <      .0020 <      .0020 <      .0010 <      .0020 <      .0040
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000       0.0000      28.0000      32.0000      30.0000      22.0000      19.0000
TOTAL ELEM      206.2954     148.3641     352.7385      98.8296     202.3332     148.0377     144.2332
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POND A GROUND WELL 2--- AEROSPACE ---


WELL DESIG          GWA2        GWA2        GWA2        GWA2        GWA2
DATE         740904.0000 741028.0000 750428.0000 751103.0000 760415.0000
REC NO.        2520.0000   2540.0000   2560.0000   2580.0000   2600.0000
PH                8.7100      8.7200      7.4000      7.7200      7.4800
ALKALINITY      389.0000    330.0000     55.0000    155.0000     82.0000
CHLORIDE         64.0000     73.0000     43.0000     56.0000     44.0000
COD              20.0000     40.0000      5.0000     40.0000      0.0000
COND            770.0000    690.0000    370.0000    420.0000    290.0000
TDS             488.0000    440.0000    248.0000    344.0000    190.0000
TSS               0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE          22.0000     51.0000    175.0000     90.0000     70.0000
ARSENIC            .0050       .0050       .0050       .0060       .0010
BORON              .4000       .2000       .1000       .1000      1.5000
CALCIUM          15.0000     15.0000     28.0000     32.0000     27.0000
LEAD               .0400       .0300       .0200       .0200       .0100
MAGNESIUM        74.0000     70.0000     13.4000     19.0000     11.0000
MERCURY            .0005      0.0000       .0004       .0002       .0008
SELENIUM           .0050       .0020       .0040       .0020       .0080
SULFITE            .9000       .9000       .2000       .2000      0.0000
SODIUM            0.0000      0.0000      0.0000     33.0000     22.0000
TOTAL ELEM      176.3505    210.1370    259.7294    230.3282    175.5198
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POND B SUPERNATE

WELL DESIG       PSB         PSB         PSB         PSB         PSB         PSB         PSB         PSB
DATE         750415.0000 750428.0000 750708.0000 750901.0000 751103.0000 760106.0000 760301.0000 760503.0000
REC NO.        2620.0000   2640.0000   2660.0000   2680.0000   2700.0000   2720.0000   2740.0000   2760.0000
PH               11.5000      8.7000      8.4000      8.6000      8.3000      7.1000      7.5000      7.4000
ALKALINITY     1300.0000     79.0000     30.0000     47.0000     34.0000     29.0000     30.0000     34.0000
CHLORIDE       1500.0000    600.0000    320.0000    380.0000    320.0000    150.0000     66.0000     62.0000
COD              60.0000     25.0000     25.0000     54.0000     43.0000      8.0000     11.0000     42.0000
COND           8600.0000   2600.0000   2200.0000   3400.0000   2900.0000   1500.0000    900.0000   1800.0000
TDS            5600.0000   2200.0000   1800.0000   3000.0000   2600.0000    880.0000    770.0000   1600.0000
TSS             160.0000      8.0000      4.0000     17.0000     17.0000     11.0000      2.0000     15.0000
SULFATE         960.0000    430.0000    900.0000   1700.0000   1200.0000     94.0000    460.0000    950.0000
ARSENIC      <     .0050 <     .0050       .0100       .0050       .0200       .0050 <     .0100       .0200
BORON            63.0000     24.0000     10.0000      7.5000       .5700      0.0000       .9400      2.1000
CALCIUM        2300.0000    840.0000    510.0000    980.0000    580.0000    320.0000    270.0000    370.0000
LEAD         <     .0100       .0400 <     .0100       .0250 <     .0100 <     .0100       .0100       .0100
MAGNESIUM          .2000      4.2000      2.8000      3.2000      6.9000      3.9000      2.7000      4.0000
MERCURY            .0002 <     .0002       .0003 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM           .0900 <     .0020       .0050       .0030 <     .0010 <     .0020       .0040 <     .0040
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            0.0000      0.0000     21.0000     40.0000     30.0000      9.3000      6.7000     15.0000
TOTAL ELEM     4823.3052   1698.2472   1763.8253   3110.7332   2137.5012    577.2172    806.3642   1423.9342


POND B SUPERNATE

WELL DESIG       PSB         PSB         PSB         PSB         PSB         PSB         PSB         PSB
DATE         760706.0000 770302.0000 770504.0000 770707.0000 770926.0000 771104.0000 771216.0000 780316.0000
REC NO.        2780.0000   2800.0000   2820.0000   2840.0000   2860.0000   2880.0000   2900.0000   2920.0000
PH                7.1000      7.4000      6.9000      7.0000      7.2000      7.2000      7.0000      7.3000
ALKALINITY       36.0000     43.0000     35.0000     40.0000     34.0000     36.0000     28.0000     28.0000
CHLORIDE         23.0000     62.0000     32.0000     56.0000     48.0000     58.0000     17.0000      8.0000
COD              25.0000     21.0000     19.0000     43.0000     44.0000     30.0000     10.0000      8.0000
COND            700.0000   1500.0000   1100.0000   1600.0000   1600.0000   2400.0000    790.0000    590.0000
TDS             460.0000   1600.0000   1200.0000   1900.0000   1400.0000   2300.0000    560.0000    430.0000
TSS               4.0000      5.0000      6.0000     10.0000      8.0000      9.0000      6.0000      5.0000
SULFATE         330.0000   1100.0000    810.0000   1300.0000    750.0000   1500.0000    350.0000     64.0000
ARSENIC      <     .0050       .0110       .0240       .0350       .0500       .0060 <     .0020       .0040
BORON             1.0000       .8000      2.2000      3.4000      2.2000      3.5000       .5400       .1300
CALCIUM         160.0000    450.0000    370.0000    500.0000    410.0000    960.0000    200.0000    100.0000
LEAD         <     .0100      0.0000 <     .0100 <     .0100 <     .0100 <     .0100       .0100 <     .0100
MAGNESIUM         2.1000      6.3000      4.2000      3.3000      3.3000      4.8000      2.3000      1.6000
MERCURY      <     .0002 <     .0002       .0006       .0002       .0016 <     .0002 <     .0002 <     .0002
SELENIUM           .0010       .0040 <     .0040       .0040 <     .0010       .0020 <     .0020 <     .0020
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            5.1000     12.0000      7.0000     10.0000      8.9000     12.0000      4.4000      2.5000
TOTAL ELEM      521.2162   1631.1162   1225.4366   1872.7492   1222.4636   2538.3182    574.2542    176.2462
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POND B SUPERNATE

WELL DESIG         PSB         PSB         PSB         PSB         PSB         PSB         PSB         PSB
DATE       780511.0000 780905.0000 781206.0000 790312.0000 790521.0000 790711.0000 790907.0000 791107.0000
REC NO.      2940.0000   2960.0000   2980.0000   3000.0000   3020.0000  16040.0000  16060.0000  14620.0000
PH              7.2000      8.4000      7.2000      7.1000      7.4000      7.4000      6.9000      7.2000
ALKALINITY     38.0000     54.0000     32.0000     34.0000     61.0000     40.0000     38.0000     38.0000
CHLORIDE       14.0000     40.0000     17.0000     10.0000     11.0000     18.0000     22.0000     36.0000
COD            19.0000     48.0000     18.0000      7.0000     18.0000     20.0000     18.0000     21.0000
COND         1600.0000   2700.0000    950.0000    630.0000    880.0000   1500.0000   1400.0000   1600.0000
TDS          1400.0000   2700.0000    680.0000    460.0000    730.0000   1400.0000   1400.0000   1300.0000
TSS             6.0000     37.0000      6.0000      1.0000      5.0000     12.0000      7.0000    130.0000
SULFATE       800.0000   1400.0000    480.0000    380.0000    380.0000    880.0000    780.0000    150.0000
ARSENIC         .0170       .0110 <     .0040       .0050       .0100       .0520       .0390       .0190
BORON           .8000      4.9000       .7600      3.4000      1.0000      2.0000       .2900      1.8000
CALCIUM       410.0000    860.0000    220.0000     19.0000    230.0000    360.0000    400.0000    520.0000
LEAD            .0150 <     .0100 <     .0100 <     .0100       .0590       .0110 <     .0100       .0270
MAGNESIUM       3.8000      7.1000      2.6000      2.7000      3.1000      3.8000      3.2000      5.1000
MERCURY    <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM        .0010       .0060       .0040       .0010       .0030       .0010       .0040       .0010
SULFITE         0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          3.8000     14.0000      1.0000      2.7000      2.5000      4.5000      5.5000      6.8000
TOTAL ELEM   1232.4332   2326.0272    721.3782    417.8162    627.6722   1268.3642   1211.0432    719.7472
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POND B SUPERNATE

WELL DESIG         PSB         PSB         PSB
DATE       800111.0000 800311.0000 800515.0000
REC NO.     14640.0000  17240.0000  17740.0000
PH              7.1000      7.2000      7.6000
ALKALINITY     41.0000     48.0000     40.0000
CHLORIDE       10.0000     12.0000     23.0000
COD             9.0000     20.0000     33.0000
COND          620.0000    880.0000   2100.0000
TDS           480.0000    750.0000   1900.0000
TSS             3.0000      7.0000     18.0000
SULFATE       270.0000    400.0000   1200.0000
ARSENIC         .0080       .0400       .0110
BORON           .0600       .6100      1.9500
CALCIUM       140.0000    170.0000    540.0000
LEAD       <     .0100 <     .0100       .0020
MAGNESIUM       2.7000      3.3000      6.0000
MERCURY    <     .0002 <     .0002 <     .0002
SELENIUM        .0010 <     .0010       .0010
SULFITE         0.0000      0.0000      0.0000
SODIUM          4.2000      3.2000      6.3000
TOTAL ELEM    426.9792    589.1612   1777.2642
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POND B SUPERNATE    --- AEROSPACE ---

WELL DESIG        PSB         PSB         PSB         PSB         PSB         PSB         PSB         PSB
DATE       750415.0000 751103.0000 760503.0000 760518.0000 770504.0000 780309.0000 790314.0000 791107.0000
REC NO.      3040.0000   3060.0000   3080.0000   3100.0000   3120.0000   3140.0000   3160.0000  16260.0000
PH             12.1500      6.7900      6.7000      7.3500      6.9900      7.8000      7.2000      6.4000
ALKALINITY   1294.0000     35.0000     34.0000     30.0000     31.0000     16.0000     34.0000     32.6000
CHLORIDE     2400.0000    400.0000    117.0000    130.0000    126.0000      3.5000     18.0000     24.0000
COD             0.0000     50.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND         7900.0000   2700.0000   1810.0000   1420.0000   1230.0000    110.0000    617.0000   1450.0000
TDS          5560.0000   2670.0000   1780.0000   1460.0000   1098.0000    102.0000    520.0000   1492.0000
TSS             0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE      1875.0000   1500.0000   1100.0000    775.0000    775.0000     24.0000    250.0000    850.0000
ARSENIC          .0040       .0100       .0120       .0010       .0060 <     .0040       .0200       .0100
BORON          86.0000      4.4000      3.0000      1.8000       .9500 <     .5000       .5000      1.8000
CALCIUM      1740.0000    580.0000    400.0000    300.0000    340.0000     18.0000    150.0000    280.0000
LEAD             .3900 <     .0100 <     .0100       .0100       .0250       .2000 <     .0900       .0600
MAGNESIUM       0.0000     10.0000      5.0000      4.0000      3.2000      1.5000      6.0000      5.9000
MERCURY          .0001       .0004       .0006       .0012 <     .0001       .0007       .0017 <     .0002
SELENIUM         .0890       .0180       .0650       .0360       .0013       .0003       .0050       .0030
SULFITE        70.0000       .2000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM         34.0000     28.0000     15.0000     11.0000      7.2000      1.5000      3.4000     10.8000
TOTAL ELEM   6205.4831   2522.6384   1640.0876   1221.8482   1252.3824     49.2050    428.0167   1172.5732
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POND B LEACHATE

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WELL DESIG           LWB           LWB           LWB           LWB           LWB           LWB           LWB           LWB
DATE         750415.0000   750422.0000   750428.0000   750707.0000   750901.0000   751103.0000   760106.0000   760301.0000
REC NO.        3180.0000     3200.0000     3220.0000     3240.0000     3260.0000     3280.0000     3300.0000     3320.0000
PH                0.0000        6.0000        6.9000       10.1000        9.1000        6.2000        7.3000        7.0000
ALKALINITY        0.0000        8.0000       22.0000      250.0000       70.0000        8.0000       39.0000       34.0000
CHLORIDE          0.0000      620.0000      460.0000      940.0000      880.0000      860.0000      630.0000      290.0000
COD              14.0000       92.0000       42.0000     1200.0000       98.0000       35.0000       13.0000       12.0000
COND              0.0000        0.0000        0.0000     3400.0000     3900.0000     3700.0000     3100.0000     2600.0000
TDS               0.0000        0.0000     1800.0000     2600.0000     2500.0000     2600.0000     2700.0000     2400.0000
TSS               0.0000        0.0000       18.0000    12000.0000     2600.0000        6.0000      130.0000       49.0000
SULFATE           0.0000      440.0000      530.0000      490.0000      360.0000      620.0000      890.0000     1200.0000
ARSENIC            .0050         .0100         .0500         .0400         .0200         .0250         .0150         .0200
BORON       <      .1000        1.0000        0.0000        3.2000         .9000         .2600        0.0000         .9600
CALCIUM         290.0000      470.0000      530.0000        0.0000      570.0000      620.0000      840.0000      790.0000
LEAD               .0900         .0240         .0280         .0490         .0160  <      .0100         .0470         .0580
MAGNESIUM        44.0000       36.0000       35.0000       57.0000        2.6000       27.0000       25.0000       14.0000
MERCURY            .0016  <      .0002         .0038         .0007         .0014  <      .0002         .0005  <      .0002
SELENIUM           .0100         .0620         .1300         .2000         .0230         .0040         .0040  <      .0040
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            0.0000        0.0000        0.0000       70.0000      160.0000      150.0000      110.0000       68.0000
TOTAL ELEM      334.2066     1567.0962     1555.2118     1560.4897     1973.5604     2277.2992     2495.0665     2363.0422
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POND B LEACHATE

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WELL DESIG           LWB
DATE         760503.0000
REC NO.        3340.0000
PH                7.9000
ALKALINITY      120.0000
CHLORIDE        130.0000
COD              43.0000
COND           1600.0000
TDS            1400.0000
TSS             530.0000
SULFATE         980.0000
ARSENIC            .0100
BORON             1.1000
CALCIUM         380.0000
LEAD        <      .0100
MAGNESIUM         7.7000
MERCURY     <      .0002
SELENIUM    <      .0040
SULFITE           0.0000
SODIUM           19.0000
TOTAL ELEM     1517.8242
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POND B LEACHATE      --- AEROSPACE ---

WELL DESIG          LWB          LWB          LWB          LWB
DATE         750415.0000  751103.0000  760121.0000  760503.0000
REC NO.        3360.0000    3380.0000    3400.0000    3420.0000
PH                6.7300       6.1800       7.3700       7.0700
ALKALINITY       28.0000      10.0000       2.0000       0.0000
CHLORIDE        140.0000    1100.0000     520.0000     139.0000
COD               0.0000      50.0000      50.0000       0.0000
COND            300.0000    3570.0000    2700.0000    1790.0000
TDS             320.0000    2670.0000    2540.0000    1690.0000
TSS               0.0000       0.0000       0.0000       0.0000
SULFATE         150.0000     675.0000    1100.0000    1000.0000
ARSENIC            .0050        .0040        .0110       0.0000
BORON             1.0000       1.0000       1.3000       3.8000
CALCIUM          28.0000     400.0000     525.0000     450.0000
LEAD               .0200  <     .0100        .0100  <     .0100
MAGNESIUM         8.0000      26.0000      27.0000      11.0000
MERCURY            .0004        .0002        .0007       0.0000
SELENIUM           .0080        .0160        .0090       0.0000
SULFITE            .1000        .1000       0.0000       0.0000
SODIUM            0.0000     158.0000      83.0000      23.0000
TOTAL ELEM      327.1334    2360.1302    2256.3307    1626.8100
```

POND B LEACHATE 1

WELL DESIG	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1
DATE	760706.0000	760720.0000	770302.0000	770504.0000	770707.0000	770926.0000	771104.0000	771216.0000
REC NO.	3440.0000	3460.0000	3480.0000	3500.0000	3520.0000	3540.0000	3560.0000	3580.0000
PH	7.5000	7.3000	6.6000	6.5000	7.1000	7.0000	6.2000	6.4000
ALKALINITY	84.0000	66.0000	24.0000	34.0000	28.0000	30.0000	12.0000	18.0000
CHLORIDE	930.0000	130.0000	340.0000	440.0000	420.0000	370.0000	300.0000	290.0000
COD	64.0000	63.0000	42.0000	36.0000	15.0000	29.0000	15.0000	17.0000
COND	2500.0000	1800.0000	2600.0000	2800.0000	2700.0000	3400.0000	3100.0000	2900.0000
TDS	2500.0000	1900.0000	3100.0000	3200.0000	3200.0000	3100.0000	2800.0000	2900.0000
TSS	870.0000	200.0000	11.0000	30.0000	10.0000	8.0000	9.0000	36.0000
SULFATE	750.0000	1200.0000	1600.0000	1700.0000	1600.0000	1600.0000	1500.0000	1500.0000
ARSENIC	.0800	.0200	.0020	.0140	.0090	.0110	.0040	.0020
BORON	1.9000	2.2000	.3700	2.7000	2.4000	2.6000	2.0000	1.2000
CALCIUM	630.0000	620.0000	570.0000	690.0000	720.0000	710.0000	890.0000	790.0000
LEAD	.0290	< .0100	< .0100	.0160	< .0100	.0100	< .0100	< .0100
MAGNESIUM	27.0000	8.4000	19.0000	20.0000	19.0000	19.0000	16.0000	18.0000
MERCURY	< .0002	.0002	< .0002	.0008	< .0002	.0002	< .0002	.0002
SELENIUM	.0080	< .0010	.0050	.0060	.0100	.0020	< .0010	.0100
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	23.0000	23.0000	82.0000	84.0000	71.0000	90.0000	78.0000	82.0000
TOTAL ELEM	2362.0172	1983.6312	2611.3872	2936.7368	2832.4292	2791.6232	2786.0152	2681.2222

POND B LEACHATE 1

WELL DESIG	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1	LWB1
DATE	780316.0000	780511.0000	780905.0000	781206.0000	790525.0000	790716.0000	790912.0000	791107.0000
REC NO.	3600.0000	3620.0000	3640.0000	3660.0000	3680.0000	15920.0000	15940.0000	14660.0000
PH	7.6000	7.2000	7.1000	7.3000	7.0000	6.8000	7.1000	6.7000
ALKALINITY	70.0000	30.0000	140.0000	51.0000	38.0000	35.0000	38.0000	24.0000
CHLORIDE	88.0000	86.0000	140.0000	190.0000	5.0000	75.0000	69.0000	100.0000
COD	7.0000	42.0000	91.0000	20.0000	26.0000	14.0000	8.0000	7.0000
COND	2100.0000	2200.0000	2100.0000	3200.0000	2200.0000	2500.0000	2300.0000	2600.0000
TDS	1900.0000	1900.0000	1600.0000	2800.0000	2200.0000	2500.0000	2400.0000	2600.0000
TSS	250.0000	8.0000	300.0000	240.0000	5.0000	15.0000	11.0000	140.0000
SULFATE	890.0000	940.0000	1000.0000	1600.0000	1300.0000	1400.0000	1200.0000	1600.0000
ARSENIC	.0040	.0190	.0120	.0090	.0060	.0190	.0270	.0650
BORON	.3000	4.0000	4.6000	3.4000	2.4000	4.1000	2.1000	.1000
CALCIUM	820.0000	500.0000	840.0000	550.0000	610.0000	630.0000	520.0000	620.0000
LEAD	< .0100	.0100	.0170	.1300	.0310	< .0100	< .0100	< .0100
MAGNESIUM	8.6000	7.1000	17.0000	15.0000	7.7000	7.1000	8.2000	8.6000
MERCURY	< .0002	.0008	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002
SELENIUM	.0020	.0020	.0130	.0040	.0020	< .0010	.0040	< .0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	31.0000	22.0000	62.0000	45.0000	22.0000	26.0000	20.0000	29.0000
TOTAL ELEM	1837.9162	1559.1318	2063.6422	2403.5432	1947.1392	2142.2302	1819.3412	2357.7772

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POND B LEACHATE 1


WELL DESIG          LWB1         LWB1
DATE         800311.0000  800515.0000
REC NO.       17160.0000   17680.0000
PH                6.6000       6.6000
ALKALINITY       17.0000     140.0000
CHLORIDE         63.0000      84.0000
COD              14.0000      18.0000
COND           2600.0000    2400.0000
TDS            2400.0000    2300.0000
TSS              26.0000      88.0000
SULFATE        1400.0000    1400.0000
ARSENIC            .0420        .0190
BORON             2.2000       1.8100
CALCIUM         420.0000     650.0000
LEAD       <       .0100        .0040
MAGNESIUM         7.9000       8.0000
MERCURY            .0002  <     .0002
SELENIUM   <       .0010  <     .0010
SULFITE           0.0000       0.0000
SODIUM           24.0000      25.0000
TOTAL ELEM     1917.1532    2168.8342


POND B LEACHATE 1   --- AEROSPACE ---


WELL DESIG          LWB1         LWB1         LWB1         LWB1         LWB1
DATE         770203.0000  770405.0000  780309.0000  780316.0000  791107.0000
REC NO.        3700.0000    3720.0000    3740.0000    3760.0000   16220.0000
PH                6.9300       6.6600       7.3000       7.2100       6.6700
ALKALINITY       18.0000      19.0000      20.2000      18.0000      21.2000
CHLORIDE        380.0000     460.0000     300.0000     150.0000     320.0000
COD               0.0000       0.0000       0.0000       0.0000       0.0000
COND           3080.0000    3150.0000    2310.0000    2290.0000    3020.0000
TDS            2882.0000    2912.0000    2324.0000    2380.0000    2528.0000
TSS               0.0000       0.0000       0.0000       0.0000       0.0000
SULFATE        1725.0000    1475.0000    1325.0000    1400.0000    1650.0000
ARSENIC            .0020  <     .0010        .0780       0.0000        .0200
BORON             2.6000       1.3000       1.0000       1.0000       2.6000
CALCIUM         670.0000     710.0000     480.0000     490.0000     430.0000
LEAD               .0400        .2600        .2700       0.0000        .0400
MAGNESIUM        21.0000      18.5000      12.0000      14.0000      14.4000
MERCURY    <       .0001  <     .0001  <     .0001       0.0000  <     .0001
SELENIUM           .0013  <     .0006        .0001       0.0000        .0050
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM           86.0000      82.0000      35.0000      30.0000      38.0000
TOTAL ELEM     2884.6434    2747.0617    2153.3482    2085.0000    2455.0651
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POND B LEACHATE 2

WELL DESIG        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2
DATE       760720.0000 770504.0000 770707.0000 770926.0000 771104.0000 771216.0000 780316.0000 780511.0000
REC NO.      3780.0000   3800.0000   3820.0000   3840.0000   3860.0000   3880.0000   3900.0000   3920.0000
PH              7.4000      6.7000      6.7000      3.6000      3.7000      4.4000      5.5000      4.4000
ALKALINITY     92.0000     79.0000     28.0000      0.0000      0.0000      0.0000      4.0000      0.0000
CHLORIDE      660.0000    220.0000    500.0000    300.0000    360.0000    280.0000    240.0000    240.0000
COD            60.0000     37.0000     73.0000    100.0000     64.0000     66.0000     64.0000     16.0000
COND         2800.0000   2400.0000   2900.0000   3400.0000   3400.0000   2800.0000   2900.0000   3000.0000
TDS          2800.0000   2800.0000   3400.0000   3100.0000   2900.0000   2600.0000   2600.0000   2700.0000
TSS           690.0000    140.0000    700.0000    150.0000     55.0000    120.0000    110.0000     46.0000
SULFATE       970.0000   1300.0000   1900.0000   1600.0000   1600.0000   1400.0000    980.0000   1500.0000
ARSENIC          .0200       .0940       .0940       .0170       .0060       .0060       .0090       .0400
BORON           2.1000      3.8000      2.5000      1.7000       .6400       .9000      8.0000      1.0000
CALCIUM       800.0000    680.0000    640.0000    530.0000    790.0000    730.0000    620.0000    690.0000
LEAD             .0180 <     .0100 <     .0100       .0190 <     .0100       .0780 <     .0100       .0100
MAGNESIUM      26.0000     18.0000     15.0000      5.2000      2.5000      4.2000     11.0000      7.3000
MERCURY          .0005 <     .0002       .0004 <     .0007 <     .0002 <     .0002 <     .0002       .0009
SELENIUM         .0020       .0060       .0200       .0150       .0130 <     .0020       .0040       .0050
SULFITE         0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM        110.0000     44.0000    100.0000     89.0000     81.0000     69.0000     42.0000     47.0000
TOTAL ELEM   2568.1405   2265.9102   3157.6244   2525.9517   2834.1692   2484.1862   1901.0232   2485.3559


POND B LEACHATE 2

WELL DESIG        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2        LWB2
DATE       780905.0000 781211.0000 790521.0000 790716.0000 790912.0000 791107.0000 800114.0000 800314.0000
REC NO.      3940.0000   3960.0000   3980.0000  15960.0000  15980.0000  14680.0000  14700.0000  17180.0000
PH              7.5000      7.0000      6.8000      6.8000      6.6000      7.0000      7.2000      2.3000
ALKALINITY    120.0000     58.0000     92.0000     62.0000     55.0000     70.0000     79.0000     56.0000
CHLORIDE       48.0000     46.0000     30.0000     32.0000     29.0000     32.0000     22.0000    190.0000
COD            63.0000     16.0000     10.0000     36.0000     39.0000     15.0000     12.0000     15.0000
COND         2800.0000   2400.0000   2200.0000   2800.0000   2400.0000   2300.0000   2400.0000   4000.0000
TDS          2800.0000   2300.0000   2200.0000   2500.0000   2700.0000   2600.0000   2200.0000   3400.0000
TSS          2000.0000     40.0000     55.0000     14.0000     27.0000     48.0000      4.0000      7.0000
SULFATE      1900.0000   1500.0000   1600.0000   1400.0000   1800.0000   1600.0000   1400.0000   2100.0000
ARSENIC          .0560       .0090       .0260       .0150       .0300       .0420       .0530       .0060
BORON           3.4000      2.9000      3.0000       .6000       .5300      3.8000      1.8000      3.0000
CALCIUM       730.0000    530.0000    830.0000    710.0000    680.0000    500.0000    640.0000    470.0000
LEAD      <      .0100 <     .0100       .0230 <     .0100 <     .0100       .0180 <     .0100 <     .0100
MAGNESIUM      14.0000     12.0000      9.7000      9.6000     12.0000     19.0000     14.0000     22.0000
MERCURY   <      .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002       .0002
SELENIUM         .0220       .0020      0.0000       .0020       .0020       .0040       .0010 <     .0010
SULFITE         0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM         20.0000     11.0000     10.0000     13.0000      9.6000     12.0000     11.0000    340.0000
TOTAL ELEM   2715.5182   2101.9212   2482.7492   2165.2272   2531.3722   2166.8642   2088.8642   3125.0172
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POND B LEACHATE 2

WELL DESIG          LWB2
DATE         800515.0000
REC NO.       17700.0000
PH                6.6000
ALKALINITY       34.0000
CHLORIDE         34.0000
COD              27.0000
COND           2600.0000
TDS            2500.0000
TSS              23.0000
SULFATE        1300.0000
ARSENIC            .0170
BORON             2.7800
CALCIUM         800.0000
LEAD               .0020
MAGNESIUM         9.2000
MERCURY     <      .0002
SELENIUM           .0010
SULFITE           0.0000
SODIUM           10.0000
TOTAL ELEM     2156.0002


POND B LEACHATE 2   --- AEROSPACE ---

WELL DESIG          LWB2          LWB2          LWB2          LWB2          LWB2
DATE         770302.0000   770504.0000   780309.0000   780316.0000   791107.0000
REC NO.        4000.0000     4020.0000     4040.0000     4060.0000    16240.0000
PH                2.9100        6.7400        4.5700        4.3500        6.7000
ALKALINITY        0.0000       72.0000        0.0000        0.0000       66.0000
CHLORIDE        310.0000      275.0000      560.0000      340.0000       25.0000
COD               0.0000        0.0000        0.0000        0.0000        0.0000
COND           2880.0000     2650.0000     2570.0000     2590.0000     2000.0000
TDS            2638.0000     2614.0000     2416.0000     2516.0000     2402.0000
TSS               0.0000        0.0000        0.0000        0.0000        0.0000
SULFATE        1550.0000     1650.0000     1300.0000     1325.0000     1475.0000
ARSENIC            .0140         .0010         .0300        0.0000         .0080
BORON             2.5000        1.9500        2.1000        1.6000        4.0000
CALCIUM         610.0000      700.0000      500.0000      550.0000      405.0000
LEAD               .0550         .2500         .2300        0.0000         .0800
MAGNESIUM        12.0000       12.6000       10.0000        6.0000       13.7000
MERCURY            .0001  <      .0001         .0010        0.0000         .0007
SELENIUM           .0020         .0017         .0004        0.0000         .0007
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           60.0000       45.0000       50.0000       48.0000       12.0000
TOTAL ELEM     2544.5711     2684.8028     2362.3614     2271.4000     1934.7894
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POND B GROUND WELL 1

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WELL DESIG          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1
DATE         750415.0000   750422.0000   750428.0000   750708.0000   750901.0000   751103.0000   760106.0000   760301.0000
REC NO.        4080.0000     4100.0000     4120.0000     4140.0000     4160.0000     4180.0000     4200.0000     4220.0000
PH                6.9000        6.9000        6.9000        6.9000        6.7000        6.9000        6.7000        6.0000
ALKALINITY      240.0000      240.0000      240.0000      240.0000      210.0000      190.0000      170.0000      170.0000
CHLORIDE         68.0000       64.0000       66.0000       82.0000       66.0000       91.0000      170.0000      140.0000
COD               0.0000       40.0000      210.0000     1400.0000       18.0000        6.0000       16.0000        9.0000
COND            610.0000        0.0000      720.0000      690.0000      660.0000      650.0000      910.0000      840.0000
TDS             420.0000      490.0000      300.0000      510.0000      530.0000        0.0000      500.0000      520.0000
TSS             120.0000       19.0000       23.0000     1000.0000      450.0000      130.0000     4200.0000      250.0000
SULFATE          24.0000       28.0000       23.0000       24.0000       42.0000       42.0000       68.0000       42.0000
ARSENIC      <     .0050   <     .0250   <     .0050   <     .0050   <     .0050   <     .0050   <     .0050         .0100
BORON              .1300         .1400         .1300         .1400         .7000         .2600         .2400         .0200
CALCIUM          31.0000       43.0000        0.0000        0.0000       61.0000       35.0000      100.0000       72.0000
LEAD               .1600         .0560        0.0000        0.0000         .0720         .1000         .5600         .0270
MAGNESIUM        15.0000       16.0000        0.0000        0.0000       15.0000       15.0000       27.0000       18.0000
MERCURY            .0059         .0007         .0008         .0005   <     .0002   <     .0002   <     .0002   <     .0002
SELENIUM     <     .0020   <     .0020   <     .0020   <     .0020   <     .0020         .0120   <     .0020         .0040
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            0.0000        0.0000        0.0000        0.0000       69.0000        0.0000       95.0000      130.0000
TOTAL ELEM      138.3229      151.2037       69.1378      106.1475      273.7792      183.4572      460.8272      402.0612
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POND B GROUND WELL 1

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WELL DESIG          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1          GWB1
DATE         760503.0000   760712.0000   760914.0000   761109.0000   770504.0000   770707.0000   771216.0000   780316.0000
REC NO.        4240.0000     4260.0000     4280.0000     4300.0000     4320.0000     4340.0000     4360.0000     4380.0000
PH                7.1000        7.3000        7.1000        6.9000        6.9000        7.0000        7.2000        7.0000
ALKALINITY      190.0000      200.0000      200.0000      180.0000      180.0000      170.0000      220.0000       75.0000
CHLORIDE         88.0000       93.0000      150.0000      160.0000      100.0000      180.0000      120.0000       96.0000
COD              23.0000       11.0000       10.0000       18.0000        4.0000       16.0000       26.0000       54.0000
COND            740.0000      700.0000      770.0000      790.0000      680.0000      870.0000     1000.0000      770.0000
TDS             450.0000      460.0000      550.0000      630.0000      460.0000      600.0000      690.0000      470.0000
TSS            2500.0000      270.0000     1100.0000      820.0000      200.0000     1500.0000    11000.0000      220.0000
SULFATE         120.0000       22.0000       36.0000       82.0000       60.0000       79.0000       84.0000       39.0000
ARSENIC      <     .0050   <     .0050   <     .0050         .0120         .0200         .1500         .0090   <     .0020
BORON              .1000         .8000         .1600         .1600        1.0000         .2200         .7700         .3000
CALCIUM          55.0000       41.0000       45.0000       42.0000       53.0000       33.0000       69.0000       49.0000
LEAD               .1100         .3600         .0040         .0290         .0400   <     .0100   <     .0100         .0350
MAGNESIUM        14.0000       16.0000       16.0000       19.0000       12.0000       21.0000        4.2000       16.0000
MERCURY      <     .0002         .0003   <     .0002         .0013         .0005         .0011         .0032   <     .0002
SELENIUM           .0040         .0030         .0040         .0040   <     .0040         .0040   <     .0020   <     .0020
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           74.0000       97.0000       11.0000      140.0000      100.0000      160.0000      160.0000        2.3000
TOTAL ELEM      351.2192      270.1603      258.2532      443.2063      326.8725      473.3851      437.9942      202.6392
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POND B GROUND WELL 1

WELL DESIG           GWB1         GWB1         GWB1         GWB1         GWB1         GWB1         GWB1         GWB1
DATE          780511.0000  780620.0000  780928.0000  790122.0000  790524.0000  790713.0000  790912.0000  791108.0000
REC NO.         4400.0000    4420.0000    4440.0000    4460.0000    4480.0000   15400.0000   15420.0000   14720.0000
PH                 7.2000       7.0000       7.4000       6.9000       7.2000       7.4000       7.1000       7.1000
ALKALINITY       170.0000     170.0000     190.0000     170.0000     150.0000     150.0000     170.0000     150.0000
CHLORIDE          84.0000      72.0000     120.0000      59.0000       8.0000      32.0000      62.0000      26.0000
COD               13.0000       9.0000      20.0000      26.0000      10.0000      14.0000       6.0000       9.0000
COND             690.0000     750.0000     840.0000     720.0000     700.0000     800.0000     780.0000     610.0000
TDS              540.0000     410.0000     660.0000     440.0000     520.0000     580.0000     600.0000     430.0000
TSS              620.0000     340.0000    6600.0000     120.0000      26.0000      14.0000     250.0000      37.0000
SULFATE           56.0000     310.0000      92.0000     110.0000     230.0000     240.0000     170.0000     140.0000
ARSENIC             .0390 <      .0040        .0060 <      .0020        .0020        .0060        .0040        .0030
BORON               .0600        .3300        .5200        .5100       1.1000        .1600        .4400        .4000
CALCIUM           54.0000      47.0000      46.0000      74.0000     170.0000     130.0000     100.0000     150.0000
LEAD                .1100        .0310        .0700        .1400        .0370 <      .0100 <      .0100        .0410
MAGNESIUM         14.0000      14.0000      18.0000      15.0000       9.3000       9.9000      14.0000       9.2000
MERCURY             .0019        .0016        .0008 <      .0002        .0050 <      .0002 <      .0002 <      .0002
SELENIUM            .0040        .0020        .0030        .0020 <      .0010        .0010        .0020        .0020
SULFITE            0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            65.0000      82.0000     160.0000      81.0000       6.3000      16.0000      62.0000      37.0000
TOTAL ELEM       273.2149     525.4106     376.6070     339.6542     424.7450     448.0772     408.4562     362.7262


POND B GROUND WELL 1

WELL DESIG           GWB1         GWB1         GWB1         GWB1
DATE          800115.0000  800314.0000  800510.0000  800702.0000
REC NO.        14740.0000   14800.0000   17401.0000   17940.0000
PH                 6.9000       7.4000       7.3000       7.1000
ALKALINITY       140.0000     170.0000     160.0000     170.0000
CHLORIDE          25.0000      30.0000      24.0000      44.0000
COD               14.0000      11.0000       9.0000      10.0000
COND             520.0000     600.0000     560.0000     670.0000
TDS              350.0000     520.0000     520.0000     510.0000
TSS               17.0000       6.0000       9.0000      20.0000
SULFATE           95.0000     110.0000      88.0000     100.0000
ARSENIC      <      .0020 <      .0020 <      .0020        .0090
BORON              1.3000        .5400        .3720        .4200
CALCIUM           84.0000      72.0000      89.0000      78.0000
LEAD         <      .0100 <      .0100        .0050        .0060
MAGNESIUM          8.2000      12.0000      10.0000       9.0000
MERCURY      <      .0002 <      .0002 <      .0002 <      .0002
SELENIUM            .0010        .0010        .0020        .0010
SULFITE            0.0000       0.0000       0.0000       0.0000
SODIUM            39.0000      54.0000      40.0000      59.0000
TOTAL ELEM       246.5132     266.5542     251.3612     291.2362
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POND B GROUND WELL 1--- AEROSPACE ---

WELL DESIG          GWD1        GWD1        GWD1        GWD1        GWD1        GWD1        GWD1        GWD1
DATE         750415.0000 751103.0000 760503.0000 761109.0000 770504.0000 780309.0000 780316.0000 790314.0000
REC NO.        4500.0000   4520.0000   4540.0000   4560.0000   4565.0000   4600.0000   4620.0000   4640.0000
PH                7.6300      7.0600      7.9300      7.8200      7.0400      7.9700      8.1200      7.0000
ALKALINITY [illegible].0000    169.0000    173.0000    187.0000    179.0000    196.0000    171.0000     79.0000
CHLORIDE   [illegible].0000    130.0000     88.0000    175.0000    150.0000    300.0000    290.0000     17.5000
COD        [illegible].0000     40.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND            623.0000    610.0000    660.0000    880.0000    635.0000    813.0000    833.0000    500.0000
TDS             400.0000    392.0000    354.0000    534.0000    430.0000    564.0000    546.0000    490.0000
TSS               0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE         225.0000     15.0000     60.0000     46.0000     44.0000     60.0000     90.0000    165.0000
ARSENIC            .0050       .0063       .0050       .0120       .0040       .0000      0.0000       .0200
BORON              .9000 <     .1000       .3000      2.0000       .6500      1.2000 <     .5000      1.4000
CALCIUM          48.0000     40.0000     47.0000     39.0000     35.0000     49.0000     41.0000    100.0000
LEAD               .0300 <     .0250 <     .0100       .0350       .0300       .2400      0.0000 <     .0900
MAGNESIUM        15.0000     15.0000     15.0000     13.5000     11.5000     18.0000     16.0000     18.0000
MERCURY            .0007       .0004       .0070 <     .0001 <     .0001       .0017      0.0000       .0019
SELENIUM           .0068       .0120       .0510 <     .0006 <     .0006       .0001      0.0000       .0040
SULFITE            .5200       .4000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            0.0000     85.0000     79.0000    140.0000    103.0000    115.0000    130.0000     11.4000
TOTAL ELEM      377.2617    283.5304    289.4018    415.5477    344.1847    563.4493    567.5000    305.4159
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POND B GROUND WELL 2

WELL DESIG	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2
DATE	741111.0000	741209.0000	750211.0000	750217.0000	750324.0000	750415.0000	750422.0000	750428.0000
REC NO.	4668.0000	4668.0000	4702.0000	4720.0000	4741.0000	4763.0000	4782.0000	4800.0000
PH	7.4000	6.9000	6.8000	6.7000	6.7000	6.7000	0.0000	6.7000
ALKALINITY	90.0000	58.0000	170.0000	170.0000	160.0000	160.0000	0.0000	160.0000
CHLORIDE	14.0000	66.0000	52.0000	50.0000	53.0000	52.0000	0.0000	53.0000
COD	8.0000	0.0000	15.0000	16.0000	9.0000	8.0000	14.0000	7.0000
COND	370.0000	710.0000	572.0000	579.0000	610.0000	540.0000	0.0000	531.0000
TDS	228.0000	800.0000	340.0000	330.0000	330.0000	300.0000	0.0000	310.0000
TSS	110.0000	11000.0000	0.0000	0.0000	61.0000	47.0000	0.0000	12.0000
SULFATE	47.0000	65.0000	20.0000	18.0000	14.0000	19.0000	0.0000	15.0000
ARSENIC	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050
BORON	< .1000	.4500	.4600	< .1000	< .1000	.4200	.1300	.1000
CALCIUM	35.0000	35.0000	54.0000	31.0000	52.0000	0.0000	29.0000	29.0000
LEAD	.1200	.0100	.0150	.1100	.2700	0.0000	.0440	.0300
MAGNESIUM	6.7000	8.9000	8.7000	9.0000	17.0000	0.0000	11.0000	11.0000
MERCURY	< .0002	0.0000	< .0002	.0005	.0010	.0002	.0005	.0013
SELENIUM	< .0020	< .0020	< .0020	< .0010	< .0020	.0030	.0040	.0030
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL ELEM	104.9272	215.3470	115.1722	100.2175	116.1655	71.4502	40.1655	100.1393

POND B GROUND WELL 2

WELL DESIG	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2	GWB2
DATE	750708.0000	750901.0000	751103.0000	760104.0000	760501.0000	760603.0000	760712.0000	770504.0000
REC NO.	4818.0000	4848.0000	4862.0000	4880.0000	4900.0000	4920.0000	4942.0000	4960.0000
PH	6.9000	6.8000	7.0100	7.2100	6.9000	7.2000	7.3000	6.8000
ALKALINITY	170.0000	210.0000	220.0000	270.0000	150.0000	170.0000	160.0000	170.0000
CHLORIDE	120.0000	92.0000	24.0000	52.0000	51.0000	54.0000	68.0000	72.0000
COD	18.0000	92.0000	8.0000	34.0000	4.0000	7.0000	13.0000	12.0000
COND	710.0000	801.0000	690.0000	551.0000	455.0000	546.0000	629.0000	850.0000
TDS	470.0000	540.0000	450.0000	0.0000	320.0000	346.0000	450.0000	370.0000
TSS	2300.0000	460.0000	130.0000	0.0000	603.0000	745.0000	640.0000	220.0000
SULFATE	54.0000	56.0000	39.0000	169.0000	50.0000	95.0000	65.0000	38.0000
ARSENIC	< .0050	.0070	< .0050	< .0050	.0050	< .0050	< .0050	.0040
BORON	.2800	1.1000	.2400	.2400	.1000	< .0100	.9010	.3510
CALCIUM	42.0000	65.0000	67.0000	69.0000	34.0000	37.0000	35.0000	61.0000
LEAD	< .0100	.0140	.0500	1.4000	.0450	.0110	.0110	.0400
MAGNESIUM	16.0000	16.0000	19.0000	120.0000	16.0000	11.0000	16.0000	12.0000
MERCURY	< .0002	< .0002	.0075	.0006	.0020	< .0002	< .0002	.0054
SELENIUM	< .0020	.0020	< .0010	.0020	< .0040	.0050	.0030	< .0040
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	88.0000	110.0000	85.0000	110.0000	70.0000	75.0000	100.0000	75.0000
TOTAL ELEM	300.2472	310.1232	234.3643	512.5476	199.1740	266.0312	303.7202	250.2214

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POND B GROUND WELL 2

WELL DESIG         GWB2        GWB2        GWB2        GWB2        GWB2        GWB2        GWB2        GWB2
DATE        770707.0000 771108.0000 780316.0000 780511.0000 780628.0000 780821.0000 790122.0000 790521.0000
REC NO.       4980.0000   5000.0000   5020.0000   5040.0000   5060.0000   5080.0000   5100.0000   5120.0000
PH               7.4000      7.0000      7.1000      6.8000      8.2000      7.2000      6.8000      6.9000
ALKALINITY     120.0000     74.0000    170.0000    160.0000    170.0000    160.0000    160.0000    160.0000
CHLORIDE       120.0000     88.0000     74.0000     60.0000      0.0000    100.0000     56.0000     43.0000
COD             16.0000      8.0000      0.0000      5.0000      9.0000     12.0000     13.0000     10.0000
COND           530.0000    560.0000    620.0000    620.0000    680.0000    680.0000    620.0000    570.0000
TDS            430.0000    450.0000    370.0000    380.0000    460.0000    430.0000    320.0000    380.0000
TSS           2200.0000      0.0000    140.0000     34.0000    510.0000     66.0000    160.0000     30.0000
SULFATE         30.0000     32.0000     28.0000     63.0000     50.0000     38.0000     34.0000     77.0000
ARSENIC           .1500  <    .0040  <    .0020       .0070  <    .0040       .0040       .0040       .0020
BORON             .1300       .1200       .1100       .0600       .1800       .0800       .1300       .1600
CALCIUM         25.0000     20.0000     26.0000     40.0000     33.0000     23.0000     35.0000     35.0000
LEAD       <      .0100       .0400       .1000  <    .0100       .0900       .0300       .0550       .0250
MAGNESIUM       16.0000     11.0000      9.7000     14.0000     14.0000     12.0000      9.7000     11.0000
MERCURY           .0006       .0003  <    .0002       .0004       .0007  <    .0002  <    .0002  <    .0002
SELENIUM          .0050       .0030  <    .0020       .0040       .0030       .0010       .0040       .0050
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM         100.0000     78.0000     13.0000     75.0000     84.0000    140.0000     81.0000     71.0000
TOTAL ELEM     291.2956    229.1673    150.9142    252.0814    181.2777    313.1152    215.8932    237.1922


POND B GROUND WELL 2

WELL DESIG         GWB2        GWB2        GWB2        GWB2        GWB2        GWB2        GWB2
DATE        790711.0000 790912.0000 791108.0000 800115.0000 800314.0000 800518.0000 800702.0000
REC NO.      15560.0000  15580.0000  14760.0000  14780.0000  16960.0000  17480.0000  17960.0000
PH               7.4000      7.4000      7.5000      6.7000      7.3000      7.6000      7.4000
ALKALINITY     160.0000    160.0000    170.0000    110.0000    120.0000    140.0000    150.0000
CHLORIDE        48.0000     54.0000     57.0000     32.0000     30.0000     39.0000     34.0000
COD             10.0000      5.0000      8.0000      5.0000     10.0000      6.0000      8.0000
COND           580.0000    600.0000    630.0000    490.0000    550.0000    630.0000    670.0000
TDS            370.0000    420.0000    420.0000    300.0000    240.0000    400.0000    520.0000
TSS             49.0000     39.0000    100.0000     10.0000      9.0000      6.0000     10.0000
SULFATE         78.0000     76.0000      9.0000     92.0000     95.0000     97.0000    160.0000
ARSENIC    <      .0020       .0060  <    .0020  <    .0020  <    .0020       .0020       .0050
BORON            3.0000       .2500       .0400       .8000       .1700       .1050       .1200
CALCIUM         34.0000     49.0000     75.0000     28.0000     27.0000     30.0000     34.0000
LEAD              .0210       .0100       .0490       .0450  <    .0100       .0110       .0090
MAGNESIUM        9.8000     12.0000     15.0000      7.5000      8.4000      9.4000      9.1000
MERCURY    <      .0002  <    .0002  <    .0002  <    .0002  <    .0002       .0002  <    .0002
SELENIUM          .0020       .0040       .0020       .0020       .0020       .0010  <    .0010
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          77.0000     85.0000     89.0000     91.0000     69.0000     89.0000    100.0000
TOTAL ELEM     249.8252    276.2702    245.0932    251.3492    229.5842    264.5192    337.2352
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POND B GROUND WELL 2--- AEROSPACE ---


WELL DESIG         GWB2         GWB2         GWB2         GWB2         GWB2         GWB2         GWB2
DATE        750211.0000  750415.0000  751103.0000  760503.0000  770504.0000  780316.0000  791108.0000
REC NO.       5140.0000    5160.0000    5180.0000    5200.0000    5220.0000    5240.0000   16280.0000
PH               7.5400       7.5800       7.2400       7.9100       7.3200       8.1400       6.4800
ALKALINITY     171.0000     158.0000     233.0000     337.0000     180.0000     126.0000     137.8000
CHLORIDE        80.0000      73.0000     110.0000      89.0000     105.0000     150.0000     125.0000
COD             35.0000      15.0000      10.0000       0.0000       0.0000       0.0000       0.0000
COND           530.0000     440.0000     610.0000     650.0000     540.0000     606.0000    1590.0000
TDS            320.0000     320.0000     408.0000     422.0000     352.0000     394.0000    1128.0000
TSS              0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SULFATE         18.0000     125.0000      27.0000     100.0000      28.0000      54.0000     495.0000
ARSENIC           .0050        .0050        .0040        .0010        .0090       0.0000        .0200
BORON            1.2000        .8000        .3000        .3000        .0500  <      .5000       1.7000
CALCIUM         40.0000      12.0000      24.0000      55.0000      31.0000      19.0000     120.0000
LEAD              .0500        .0900        .0100        .0100        .0300       0.0000        .0300
MAGNESIUM       12.0000      13.6000      14.0000      15.0000      11.0000       9.6000      65.9000
MERCURY           .0001        .0004        .0001        .0004        .0001       0.0000  <     .0002
SELENIUM          .0090        .0070        .0140        .0900        .0006       0.0000        .0010
SULFITE           .3000        .2700        .5000       0.0000       0.0000       0.0000       0.0000
SODIUM           0.0000       0.0000      83.0000      75.0000       7.7000     100.0000      19.0000
TOTAL ELEM     151.5641     224.7724     258.8281     334.4014     182.7897     333.1000     826.6512
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POND C SUPERNATE

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WELL DESIG          PSC           PSC           PSC           PSC           PSC           PSC           PSC           PSC
DATE        750428.0000   750505.0000   750708.0000   750901.0000   751103.0000   760106.0000   760308.0000   760503.0000
REC NO.       5260.0000     5280.0000     5300.0000     5320.0000     5340.0000     5360.0000     5380.0000     5400.0000
PH              11.2000       10.3000        8.3000        8.4000        8.3000        8.0000        7.3000        8.8000
ALKALINITY     170.0000       31.0000       21.0000       30.0000       28.0000       40.0000       41.0000       54.0000
CHLORIDE       560.0000      240.0000      440.0000      500.0000      430.0000      180.0000      430.0000      680.0000
COD             20.0000       17.0000       18.0000       19.0000       18.0000       10.0000       30.0000       35.0000
COND          2400.0000     2300.0000     2700.0000     3800.0000     3400.0000     1600.0000     3600.0000        0.0000
TDS           1600.0000     1500.0000     2100.0000     3200.0000     3000.0000     1800.0000     3800.0000     4300.0000
TSS              9.0000       31.0000        5.0000       11.0000       43.0000       82.0000        7.0000       22.0000
SULFATE        200.0000      200.0000      600.0000     1700.0000     1100.0000      890.0000     2300.0000     1600.0000
ARSENIC           .0080  <      .0050         .0070         .0060         .0050         .0150         .0050  <      .0050
BORON             .3400         .2600        1.5000        2.3000         .6700        0.0000        0.0000        1.1000
CALCIUM        590.0000      480.0000      450.0000      880.0000      600.0000      600.0000     1000.0000      560.0000
LEAD              .0160         .0360  <      .0100         .0190  <      .0100         .0250  <      .0100  <      .0100
MAGNESIUM         .2000         .4000        3.0000        5.3000        7.1000        8.4000       26.0000       18.0000
MERCURY    <      .0002  <      .0002  <      .0002  <      .0002  <      .0002         .0003  <      .0002         .0006
SELENIUM          .0030         .0020  <      .0020         .0060         .0020         .0040         .0140         .0310
SULFITE          0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           0.0000        0.0000       49.0000       75.0000       68.0000       29.0000       78.0000      120.0000
TOTAL ELEM    1350.5672      920.7032     1543.5192     3162.6312     2205.7872     1707.4443     3834.0292     2979.1466
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POND C SUPERNATE

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WELL DESIG          PSC           PSC           PSC           PSC           PSC           PSC           PSC           PSC
DATE        760706.0000   761005.0000   761109.0000   770302.0000   770505.0000   770707.0000   770926.0000   771216.0000
REC NO.       5420.0000     5440.0000     5460.0000     5480.0000     5500.0000     5520.0000     5540.0000     5560.0000
PH               7.8000        8.2000        8.0000        7.7000        6.6000        7.9000        7.4000        7.3000
ALKALINITY      37.0000       66.0000       44.0000       42.0000       30.0000       38.0000       34.0000       28.0000
CHLORIDE       500.0000      460.0000      220.0000      180.0000       45.0000       66.0000       60.0000       27.0000
COD             13.0000       51.0000       21.0000       15.0000       14.0000       17.0000       17.0000        4.0000
COND          2000.0000     3000.0000     2200.0000     2200.0000     1600.0000     2000.0000     2100.0000     1600.0000
TDS           2300.0000     3800.0000     2900.0000     2700.0000     2200.0000     2500.0000     2000.0000     1400.0000
TSS             15.0000       13.0000        6.0000        7.0000        6.0000        6.0000       13.0000        4.0000
SULFATE       1100.0000     1900.0000     2000.0000     1400.0000     1400.0000     1700.0000     1100.0000      860.0000
ARSENIC           .0200         .0350         .0120  <      .0020         .0180         .0260         .0240  <      .0020
BORON           23.0000       14.0000        7.4000        6.2000        3.1000         .5500        3.3000        1.3000
CALCIUM        460.0000      490.0000      690.0000      620.0000      540.0000      610.0000      680.0000      450.0000
LEAD       <      .0100  <      .0100  <      .0100         .0100  <      .0100  <      .0100  <      .0100  <      .0100
MAGNESIUM        7.2000       25.0000       29.0000       20.0000        7.9000        7.4000        9.0000        5.8000
MERCURY    <      .0002  <      .0002         .0002  <      .0002         .0005  <      .0002         .0015  <      .0002
SELENIUM          .0140         .0270         .0540         .0200  <      .0020         .0190         .0120         .0080
SULFITE          0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM          16.0000       76.0000       38.0000       30.0000       11.0000       15.0000       13.0000        6.1000
TOTAL ELEM    2106.2442     2965.0722     2984.4762     2256.2322     2007.0305     2399.0052     1865.3475     1350.2202
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POND C SUPERNATE


WELL DESIG           PSC         PSC         PSC         PSC
DATE         780316.0000 780511.0000 780821.0000 781211.0000
REC NO.        5580.0000   5600.0000   5620.0000   5640.0000
PH                8.0000      7.4000      7.8000      7.5000
ALKALINITY       29.0000     32.0000     50.0000     36.0000
CHLORIDE         12.0000     21.0000     62.0000     11.0000
COD               6.0000     18.0000     44.0000      5.0000
COND           1700.0000   2400.0000   3000.0000   1600.0000
TDS            1500.0000   2300.0000   3100.0000   1300.0000
TSS               4.0000     21.0000     13.0000     10.0000
SULFATE         290.0000   1500.0000   1500.0000    840.0000
ARSENIC            .0040       .0220 <     .0020       .0040
BORON              .5900      1.7000     74.0000      1.1000
CALCIUM         280.0000    670.0000    850.0000    380.0000
LEAD         <     .0100 <     .0100 <     .0100 <     .0100
MAGNESIUM         3.4000      7.5000      9.7000      6.4000
MERCURY      <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM           .0030       .0050       .0130       .0080
SULFITE           0.0000      0.0000      0.0000      0.0000
SODIUM            1.7000      6.3000     14.0000      3.1000
TOTAL ELEM      587.7072   2206.5372   2509.7252   1241.6222
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POND C SUPERNATE    --- AEROSPACE ---


WELL DESIG           PSC         PSC         PSC         PSC         PSC         PSC         PSC
DATE         750428.0000 751103.0000 760503.0000 761109.0000 770505.0000 780309.0000 780316.0000
REC NO.        5660.0000   5680.0000   5700.0000   5720.0000   5740.0000   5760.0000   5780.0000
PH               11.4300      7.3200      8.2300      7.1500      7.0900      7.3800      7.4300
ALKALINITY      173.0000     35.0000     45.0000     40.0000     26.0000     13.6000     20.0000
CHLORIDE        610.0000    540.0000    680.0000    245.0000    150.0000     12.0000     10.0000
COD              49.0000     25.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND           2400.0000   3130.0000   4540.0000   2780.0000   1960.0000    962.0000   1230.0000
TDS            1560.0000   2960.0000   4220.0000   2750.0000   1996.0000    890.0000   1204.0000
TSS               0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE         175.0000   1500.0000   1500.0000   1475.0000   1350.0000    588.0000    682.0000
ARSENIC            .0050       .0060       .0280       .0180       .0110       .0160      0.0000
BORON              .1000      2.4000      6.5000      7.8000      1.3000       .8500      1.5000
CALCIUM         340.0000    600.0000    850.0000    680.0000    550.0000    170.0000    230.0000
LEAD               .1400 <     .0100 <     .0200       .0450       .0400       .2000      0.0000
MAGNESIUM         3.7000      9.0000     22.0000     23.0000      6.9000      4.3000      4.6000
MERCURY            .0003       .0003       .0011 <     .0001 <     .0001       .0019      0.0000
SELENIUM           .0040       .0060       .1010       .0173       .0027       .0004      0.0000
SULFITE            .8500 <     .1000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            0.0000     68.0000    122.0000     48.0000     10.0000      2.0000      3.0000
TOTAL ELEM     1129.7993   2719.5223   3180.6501   2478.8804   2068.2538    777.3683    931.1000
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POND C RUNOFF

WELL DESIG          PRC         PRC         PRC         PRC         PRC
DATE        791108.0000 800114.0000 800317.0000 800518.0000 800701.0000
REC NO.      16740.0000  16760.0000  17280.0000  17780.0000  18220.0000
PH               7.2000      6.3000      7.5000      7.7000      6.9000
ALKALINITY     140.0000     65.0000     91.0000    130.0000     70.0000
CHLORIDE        12.0000     15.0000     22.0000     22.0000     75.0000
COD              5.0000     12.0000     16.0000     14.0000     39.0000
COND          1300.0000   2100.0000   2400.0000   2600.0000   2800.0000
TDS           1200.0000   2100.0000   2200.0000   2400.0000   2500.0000
TSS             10.0000     55.0000     95.0000     45.0000     57.0000
SULFATE       1500.0000   1400.0000   1800.0000   1300.0000   1400.0000
ARSENIC           .0150       .0070       .0120       .0200       .0140
BORON             .5300      2.0000      2.1000      2.1500      3.1000
CALCIUM        440.0000    620.0000    550.0000    700.0000    620.0000
LEAD        <     .0100 <     .0100       .0110       .0080       .0120
MAGNESIUM        4.9000      8.7000     11.0000     13.0000      9.0000
MERCURY     <     .0002 <     .0002 <     .0002 <     .0002       .0002
SELENIUM          .0040       .0100       .0090       .0050       .0220
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           3.8000      4.9000      5.0000      4.8000     10.0000
TOTAL ELEM    1961.2592   2050.6272   2390.1322   2041.9832   2117.1482


POND C RUNOFF       --- AEROSPACE ---

WELL DESIG          PRC         PRC         PRC
DATE        790828.0000 790921.0000 791108.0000
REC NO.      16300.0000  16320.0000  16360.0000
PH               6.8400      6.9600      6.9600
ALKALINITY     115.0000     39.0000    154.8000
CHLORIDE        38.0000     13.0000     10.0000
COD              0.0000      0.0000      0.0000
COND          1870.0000   1330.0000   1180.0000
TDS           2002.0000   1402.0000   1124.0000
TSS              0.0000      0.0000      0.0000
SULFATE       1450.0000    825.0000    675.0000
ARSENIC           .0100       .0090       .0080
BORON            3.3000      1.3000      1.0000
CALCIUM        430.0000    300.0000    230.0000
LEAD              .1000       .0500       .0600
MAGNESIUM       10.5000      8.0000      6.6000
MERCURY           .0001 <     .0002 <     .0002
SELENIUM          .0080       .0080       .0050
SULFITE          0.0000      0.0000      0.0000
SODIUM           9.8000      5.0000      2.1000
TOTAL ELEM    1941.7181   1152.3672    924.7732
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POND C LEACHATE

WELL DESIG	LWC	LWC	LWC	LWC	LWC	LWC	LWC	LWC
DATE	750428.0000	750429.0000	750505.0000	750707.0000	750901.0000	760106.0000	760301.0000	760517.0000
REC NO.	5800.0000	5820.0000	5840.0000	5860.0000	5880.0000	5900.0000	5920.0000	5940.0000
PH	10.4000	11.8000	11.9000	11.4000	9.0000	7.3000	8.1000	8.2000
ALKALINITY	99.0000	600.0000	720.0000	300.0000	44.0000	58.0000	30.0000	3.0000
CHLORIDE	2400.0000	2100.0000	2100.0000	1200.0000	1100.0000	1000.0000	380.0000	810.0000
COD	140.0000	140.0000	130.0000	1300.0000	66.0000	30.0000	18.0000	40.0000
COND	7500.0000	8500.0000	8400.0000	5600.0000	5000.0000	4000.0000	3200.0000	4000.0000
TDS	4700.0000	4600.0000	4100.0000	3200.0000	3300.0000	3500.0000	3000.0000	3800.0000
TSS	73.0000	36.0000	30.0000	2800.0000	36000.0000	370.0000	160.0000	370.0000
SULFATE	750.0000	44.0000	23.0000	190.0000	820.0000	870.0000	1000.0000	1200.0000
ARSENIC	< .0050	< .0050	< .0050	< .0050	.0200	.0200	.0200	.0200
BORON	.1900	.1300	.1000	.3700	1.4000	0.0000	2.5000	6.4000
CALCIUM	2000.0000	2000.0000	1900.0000	650.0000	550.0000	790.0000	980.0000	800.0000
LEAD	.0520	.1100	.1200	.2200	.0160	.1600	< .0100	< .0100
MAGNESIUM	5.4000	.4000	.1000	8.3000	.2000	8.8000	12.0000	8.9000
MERCURY	< .0002	< .0002	.0010	0.0000	< .0002	.0036	< .0002	.0003
SELENIUM	.0110	.0110	.0100	.0080	< .0020	.0030	.0120	.0140
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	0.0000	150.0000	180.0000	18.0000	53.0000	0.0000
TOTAL ELEM	5155.6582	4144.6562	4023.3360	2198.9030	2651.6382	2686.9866	2427.5422	2825.3443

POND C LEACHATE

WELL DESIG	LWC	LWC	LWC	LWC	LWC	LWC	LWC	LWC
DATE	760706.0000	770505.0000	770707.0000	770926.0000	780105.0000	780316.0000	780511.0000	781206.0000
REC NO.	5960.0000	5980.0000	6000.0000	6020.0000	6040.0000	6060.0000	6080.0000	6100.0000
PH	7.7000	6.9000	7.2000	7.3000	7.3000	8.0000	7.4000	7.5000
ALKALINITY	60.0000	30.0000	42.0000	69.0000	48.0000	32.0000	48.0000	65.0000
CHLORIDE	260.0000	160.0000	140.0000	260.0000	190.0000	81.0000	70.0000	73.0000
COD	42.0000	10.0000	22.0000	33.0000	21.0000	8.0000	17.0000	23.0000
COND	2600.0000	2400.0000	2400.0000	3400.0000	2700.0000	2500.0000	2600.0000	2600.0000
TDS	2900.0000	2800.0000	2800.0000	3000.0000	2400.0000	2400.0000	2400.0000	2300.0000
TSS	3900.0000	53.0000	1600.0000	2200.0000	2700.0000	47.0000	630.0000	14.0000
SULFATE	1600.0000	1700.0000	1800.0000	1600.0000	1400.0000	1300.0000	1500.0000	1500.0000
ARSENIC	.0350	.0280	.0320	.0220	.0440	.0090	.0200	.0090
BORON	15.0000	4.4000	6.4000	5.5000	4.0000	1.2000	2.8000	2.8000
CALCIUM	730.0000	620.0000	680.0000	850.0000	650.0000	540.0000	670.0000	740.0000
LEAD	.0300	< .0100	.0150	.0260	.0510	< .0100	.0420	.0270
MAGNESIUM	13.0000	9.2000	9.0000	18.0000	13.0000	8.0000	10.0000	7.9000
MERCURY	.0009	.0005	.0002	.0007	.0006	< .0002	.0007	.0003
SELENIUM	.0160	.0380	.0250	.0260	.0060	.0220	.0270	.0140
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	53.0000	27.0000	27.0000	64.0000	28.0000	17.0000	20.0000	16.0000
TOTAL ELEM	2671.0819	2520.6765	2662.4722	2797.5747	2285.1016	1947.2412	2272.8897	2339.7503

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POND C LEACHATE     --- AEROSPACE ---

WELL DESIG         LWC         LWC         LWC         LWC         LWC         LWC         LWC         LWC
DATE       750211.0000 750428.0000 760121.0000 760301.0000 760503.0000 770302.0000 770505.0000 780309.0000
REC NO.      6120.0000   6140.0000   6160.0000   6180.0000   6200.0000   6220.0000   6240.0000   6260.0000
PH              7.4600     10.6100      6.8600      0.0000      7.2600      7.3300      6.9900      7.1700
ALKALINITY     56.0000     50.0000     39.0000      0.0000     40.0000     35.0000     26.0000     17.0000
CHLORIDE       42.0000   2562.0000   1050.0000    380.0000    580.0000    420.0000    260.0000     54.0000
COD            20.0000      0.0000     60.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND          430.0000   7500.0000   4160.0000      0.0000   4090.0000   3390.0000   2530.0000   2060.0000
TDS           260.0000   4720.0000   3540.0000      0.0000   3750.0000   3120.0000   2606.0000   2160.0000
TSS             0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE       225.0000     75.0000   1175.0000   1550.0000   1500.0000   1690.0000   1675.0000   1350.0000
ARSENIC          .0050       .0050       .0210      0.0000       .0230       .0020       .0180       .0330
BORON            .1000       .1000      1.0000      0.0000      5.5000      5.0000      2.8000      2.6000
CALCIUM        20.0000   1980.0000    575.0000    600.0000    700.0000    680.0000    690.0000    450.0000
LEAD             .0400       .3600 <     .0100      0.0000 <     .0100       .0600       .2400       .2300
MAGNESIUM      14.0000      3.8000      9.0000      0.0000     12.0000     11.0000      7.0000     11.0000
MERCURY          .0003       .0001       .0012      0.0000       .0005 <     .0001 <     .0001 <     .0001
SELENIUM         .0090       .0110       .0220      0.0000       .1730       .0206       .0053       .0001
SULFITE         0.0000      4.5000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          0.0000      0.0000    143.0000      0.0000    102.0000     88.0000     26.0000     15.0000
TOTAL ELEM    301.1543   4625.7761   2953.0542   2530.0000   2899.7065   2894.0827   2661.0634   1882.8632


POND C LEACHATE     --- AEROSPACE ---

WELL DESIG         LWC
DATE       780316.0000
REC NO.      6280.0000
PH              7.0300
ALKALINITY     23.6000
CHLORIDE       62.0000
COD             0.0000
COND         2160.0000
TDS          2302.0000
TSS             0.0000
SULFATE      1388.0000
ARSENIC         0.0000
BORON           2.4000
CALCIUM       480.0000
LEAD            0.0000
MAGNESIUM      11.0000
MERCURY         0.0000
SELENIUM        0.0000
SULFITE         0.0000
SODIUM         16.0000
TOTAL ELEM   1959.4000
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POND C GROUND WELL 1

WELL DESIG          GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1
DATE         740722.0000  740729.0000  740805.0000  740903.0000  741007.0000  741209.0000  750211.0000  750423.0000
REC NO.        6300.0000    6320.0000    6340.0000    6360.0000    6380.0000    6400.0000    6420.0000    6440.0000
PH                7.7000       7.4000       7.4000       7.5000       7.0000       0.0000       6.6000       7.6000
ALKALINITY      130.0000     120.0000     130.0000      96.0000      47.0000       0.0000     130.0000      82.0000
CHLORIDE         10.0000       9.0000      10.0000       7.0000      13.0000       0.0000      14.0000      11.0000
COD               0.0000       0.0000       0.0000       0.0000       0.0000       0.0000      12.0000       7.0000
COND            400.0000     460.0000       0.0000       0.0000       0.0000       0.0000     450.0000     340.0000
TDS             380.0000     330.0000     330.0000     450.0000     370.0000       0.0000     330.0000     240.0000
TSS             720.0000      81.0000      26.0000       0.0000    1000.0000       0.0000       0.0000      12.0000
SULFATE          56.0000      85.0000      67.0000     180.0000      78.0000       0.0000      55.0000      50.0000
ARSENIC     <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050 <      .0050
BORON       <      .1000 <      .1000 <      .1000 <      .1000 <      .1000        .2000 <      .1000        .1100
CALCIUM          29.0000      34.0000      34.0000      83.0000      38.0000       0.0000      33.0000      15.0000
LEAD               .1200        .0400        .0320 <      .0100 <      .0100       0.0000        .0150        .0200
MAGNESIUM         6.1000       5.9000       5.7000      12.0000       7.3000       0.0000      48.0000       2.7000
MERCURY           0.0000       0.0000        .0003 <      .0002 <      .0002       0.0000        .0004        .0011
SELENIUM    <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020 <      .0020
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
TOTAL ELEM      101.3270     134.0470     116.8393     282.1172     136.4172        .2070     150.1224      78.8381
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POND C GROUND WELL 1

WELL DESIG          GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1
DATE         750505.0000  750708.0000  750901.0000  751103.0000  760301.0000  760503.0000  760712.0000  770505.0000
REC NO.        6460.0000    6480.0000    6500.0000    6520.0000    6540.0000    6560.0000    6580.0000    6600.0000
PH                6.7000       7.0000       6.9000       7.0000       6.5000       7.1000       6.9000       6.3000
ALKALINITY      110.0000     120.0000      80.0000      76.0000      80.0000     100.0000      76.0000      90.0000
CHLORIDE         12.0000      40.0000      13.0000      15.0000      24.0000      13.0000      14.0000      15.0000
COD               5.0000       5.0000       8.0000       7.0000       5.0000      15.0000       5.0000      13.0000
COND            450.0000     440.0000     470.0000     420.0000     360.0000     530.0000     360.0000     370.0000
TDS             420.0000     650.0000     550.0000     400.0000     330.0000     430.0000     320.0000     340.0000
TSS              28.0000    3000.0000    1200.0000     550.0000    1600.0000     160.0000      75.0000     270.0000
SULFATE          18.0000     180.0000     160.0000      88.0000      83.0000     190.0000      64.0000      64.0000
ARSENIC     <      .0050 <      .0050        .0200 <      .0050 <      .0100        .0100 <      .0050        .0020
BORON       <      .1000 <      .1000        .7000        .2400        .1200        .1200        .0700        .2800
CALCIUM          22.0000      40.0000      48.0000      33.0000     230.0000      47.0000      18.0000      24.0000
LEAD               .0220        .1500        .0630        .1500        .5200        .2400        .4100        .0300
MAGNESIUM         4.6000       9.3000       7.4000       7.1000      32.0000       3.9000       3.4000       4.2000
MERCURY            .0052        .0009        .0006 <      .0002 <      .0002 <      .0002 <      .0002        .0003
SELENIUM    <      .0050 <      .0020 <      .0020 <      .0010 <      .0040        .0070 <      .0010        .0040
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000      53.0000      54.0000      53.0000      62.0000      46.0000      54.0000      62.0000
TOTAL ELEM       56.7372     322.5579     283.1856     196.4962     431.6542     300.2772     153.8862     169.5163
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POND C GROUND WELL 1

WELL DESIG         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1
DATE        771216.0000  780316.0000  780511.0000  780628.0000  780821.0000  790122.0000  790313.0000  790522.0000
REC NO.       6620.0000    6640.0000    6660.0000    6680.0000    6700.0000    6720.0000    6740.0000    6760.0000
PH               6.5000       6.3000       6.5000       7.2000       6.8000       6.6000       6.2000       6.6000
ALKALINITY     110.0000      73.0000      76.0000      60.0000      95.0000      82.0000      70.0000     110.0000
CHLORIDE        17.0000      20.0000      24.0000      25.0000      34.0000      21.0000      36.0000      24.0000
COD             40.0000      20.0000      11.0000       7.0000       0.0000      15.0000       3.0000       6.0000
COND           460.0000     390.0000     420.0000     410.0000     450.0000     490.0000     480.0000     480.0000
TDS            430.0000     330.0000     330.0000     370.0000     440.0000     350.0000     380.0000     370.0000
TSS          12000.0000     240.0000     210.0000    2600.0000    1400.0000     180.0000      56.0000      31.0000
SULFATE         50.0000      56.0000      70.0000      66.0000      66.0000      24.0000     110.0000     110.0000
ARSENIC           .0120 <      .0020        .0050 <      .0040        .0090 <      .0020        .0030       0.0000
BORON             .2000        .1000        .1700        .2900        .1900        .1700       7.8000       0.0000
CALCIUM         34.0000      29.0000      19.0000      14.0000      32.0000      28.0000      23.0000       0.0000
LEAD              .1800        .0580 <      .0100        .0650        .0660        .1400        .0240       0.0000
MAGNESIUM        8.4000      22.0000       4.5000       3.6000       5.1000       5.2000       5.3000       0.0000
MERCURY           .0052 <      .0002 <      .0002        .0014 <      .0002 <      .0002 <      .0002       0.0000
SELENIUM  <       .0020 <      .0020 <      .0010 <      .0010        .0040 <      .0010 <      .0010       0.0000
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM          72.0000      47.0000      66.0000      57.0000      53.0000      53.0000      75.0000       0.0000
TOTAL ELEM     181.7992     174.1622     183.6862     165.9614     190.3692     131.5132     257.1282     134.0000


POND C GROUND WELL 1

WELL DESIG         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1         GWC1
DATE        790711.0000  790912.0000  791113.0000  800114.0000  800314.0000  800518.0000  800702.0000
REC NO.      15440.0000   15460.0000   14800.0000   14820.0000   16900.0000   17420.0000   17960.0000
PH               6.9000       6.7000       6.8000       6.9000       6.8000       7.3000       7.0000
ALKALINITY      62.0000      69.0000     120.0000      60.0000      52.0000      32.0000      61.0000
CHLORIDE        28.0000      20.0000      10.0000      29.0000      22.0000      20.0000      11.0000
COD             14.0000      51.0000       7.0000       4.0000      10.0000       8.0000      11.0000
COND           430.0000     550.0000     750.0000     720.0000     520.0000     490.0000     460.0000
TDS            300.0000     440.0000     790.0000     450.0000     540.0000     340.0000     290.0000
TSS             11.0000      72.0000     180.0000      70.0000       9.0000      23.0000      40.0000
SULFATE        100.0000     200.0000     265.0000     120.0000     160.0000     150.0000     110.0000
ARSENIC           .0030        .0030        .0030 <      .0020 <      .0020 <      .0020 <      .0020
BORON            1.6000       1.2000        .0800       0.0000        .0600        .0230        .1200
CALCIUM         15.0000      52.0000     180.0000      29.0000      28.0000      21.0000      26.0000
LEAD      <       .0100        .0200        .0150        .0220        .0140        .0010        .0230
MAGNESIUM        3.9000      12.0000      28.0000       5.0000       6.0000       5.2000       6.4000
MERCURY           .0003 <      .0002 <      .0002        .0005 <      .0002 <      .0002 <      .0002
SELENIUM  <       .0010        .0030        .0010 <      .0010 <      .0010        .0010        .0030
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM          81.0000      45.0000      33.0000      90.0000      63.0000      59.0000      47.0000
TOTAL ELEM     229.5143     330.2262     521.0992     273.0255     279.0772     255.2272     200.5482
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POND C GROUND WELL 1--- AEROSPACE ---

WELL DESIG         GWC1           GWC1           GWC1           GWC1           GWC1           GWC1
DATE        740904.0000    751103.0000    770505.0000    780309.0000    790314.0000    791113.0000
REC NO.       6780.0000      6800.0000      6820.0000      6860.0000      6880.0000     16340.0000
PH               8.0800         7.0800         6.8800         8.0500         7.4000         6.4200
ALKALINITY     106.0000        76.0000        94.0000        81.0000        61.6000       112.2000
CHLORIDE        61.0000        64.0000        70.0000        29.0000        50.0000         3.4000
COD              7.0000        10.0000         0.0000         0.0000         0.0000         0.0000
COND           590.0000       310.0000       360.0000       150.0000       405.0000       685.0000
TDS            460.0000       340.0000       328.0000       316.0000       354.0000       576.0000
TSS              0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
SULFATE        250.0000        70.0000        65.0000        64.0000       132.0000       265.0000
ARSENIC           .0050          .0020          .0080         0.0000          .0600          .0080
BORON             .1000          .5000  <       .0500  <       .5000  <       .1000  <       .5000
CALCIUM        480.0000        16.0000        17.0000        12.0000        14.0000       100.0000
LEAD              .0500  <       .0200          .0350         0.0000  <       .0900          .0400
MAGNESIUM       18.0000         5.0000         3.4000         4.1000         8.0000        24.3000
MERCURY           .0007          .0001  <       .0001         0.0000          .0017  <       .0002
SELENIUM          .0040          .0180          .0020         0.0000          .0190          .0030
SULFITE           .2000          .2000         0.0000         0.0000         0.0000         0.0000
SODIUM           0.0000        57.0000        53.0000        52.0000        55.0000        40.0000
TOTAL ELEM     809.3597       212.7401       208.4951       161.6000       259.2707       433.2512
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POND C GROUND WELL 2

WELL DESIG	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2
DATE	740805.0000	740903.0000	741007.0000	741209.0000	750211.0000	750423.0000	750428.0000	750505.0000
REC NO.	6900.0000	6920.0000	6940.0000	6960.0000	6980.0000	7000.0000	7020.0000	7040.0000
PH	7.3000	7.3000	7.3000	0.0000	7.2000	7.2000	7.2000	7.1000
ALKALINITY	68.0000	80.0000	99.0000	0.0000	140.0000	150.0000	150.0000	160.0000
CHLORIDE	14.0000	15.0000	26.0000	0.0000	63.0000	65.0000	66.0000	100.0000
COD	0.0000	0.0000	0.0000	0.0000	13.0000	9.0000	9.0000	18.0000
COND	0.0000	0.0000	0.0000	0.0000	610.0000	540.0000	570.0000	650.0000
TDS	230.0000	170.0000	260.0000	0.0000	320.0000	320.0000	330.0000	400.0000
TSS	210.0000	0.0000	120.0000	0.0000	0.0000	49.0000	20.0000	87.0000
SULFATE	48.0000	30.0000	30.0000	0.0000	22.0000	17.0000	23.0000	52.0000
ARSENIC	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050	< .0050
BORON	< .1000	< .1000	< .1000	< .1000	< .1000	.1700	.2000	.2500
CALCIUM	31.0000	23.0000	26.0000	0.0000	38.0000	36.0000	36.0000	44.0000
LEAD	.0240	0.0000	< .0100	0.0000	.0440	.0220	.0200	.0580
MAGNESIUM	8.6000	8.4000	8.4000	0.0000	9.4000	12.0000	18.0000	13.0000
MERCURY	.0002	< .0002	< .0002	0.0000	.0002	.0003	.0008	.0028
SELENIUM	< .0020	< .0020	< .0020	< .0020	< .0020	< .0020	< .0020	< .0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL ELEM	101.7312	76.5072	98.5172	.1070	132.5512	180.1993	140.2278	209.3178

POND C GROUND WELL 2

WELL DESIG	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2	GWC2
DATE	750708.0000	750901.0000	751103.0000	760315.0000	760503.0000	760712.0000	770505.0000	780105.0000
REC NO.	7060.0000	7080.0000	7100.0000	7120.0000	7140.0000	7160.0000	7180.0000	7200.0000
PH	7.0000	7.2000	7.3000	7.0000	8.0000	7.5000	7.2000	7.2000
ALKALINITY	130.0000	120.0000	100.0000	130.0000	150.0000	130.0000	120.0000	84.0000
CHLORIDE	110.0000	110.0000	130.0000	0.0000	25.0000	37.0000	44.0000	10.0000
COD	12.0000	10.0000	23.0000	5.0000	25.0000	5.0000	19.0000	21.0000
COND	850.0000	910.0000	980.0000	380.0000	680.0000	410.0000	480.0000	290.0000
TDS	540.0000	840.0000	650.0000	230.0000	500.0000	270.0000	370.0000	300.0000
TSS	3800.0000	2500.0000	4300.0000	850.0000	540.0000	270.0000	830.0000	4800.0000
SULFATE	110.0000	170.0000	200.0000	26.0000	240.0000	41.0000	92.0000	37.0000
ARSENIC	< .0050	< .0050	.0050	.0100	.0100	< .0050	.0130	.0340
BORON	2.5000	2.4000	.6100	.5900	.6500	.3600	.8100	.5800
CALCIUM	0.0000	120.0000	290.0000	28.0000	98.0000	37.0000	25.0000	39.0000
LEAD	0.0000	.1000	.3000	.4800	.0280	.3200	.0650	.0780
MAGNESIUM	0.0000	34.0000	84.0000	22.0000	13.0000	15.0000	16.0000	12.0000
MERCURY	.0009	< .0002	< .0002	.0002	< .0004	< .0002	.0013	.0010
SELENIUM	< .0020	< .0020	< .0010	.0030	.0040	.0010	.0060	< .0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	52.0000	59.0000	26.0000	23.0000	28.0000	58.0000	24.0000
TOTAL ELEM	222.5079	438.5072	763.9162	103.0832	399.6924	158.6862	235.8953	122.6950

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POND C GROUND WELL 2

WELL DESIG         GWC2        GWC2        GWC2        GWC2        GWC2        GWC2        GWC2        GWC2
DATE        780316.0000 780511.0000 780628.0000 780821.0000 790122.0000 790312.0000 790521.0000 790711.0000
REC NO.       7220.0000   7240.0000   7260.0000   7280.0000   7300.0000   7320.0000   7340.0000  15480.0000
PH               7.4000      7.5000      7.8000      7.7000      7.5000      7.2000      0.0000      7.5000
ALKALINITY      98.0000    100.0000    110.0000    140.0000    130.0000    130.0000      0.0000    130.0000
CHLORIDE         6.0000     20.0000     21.0000     21.0000     50.0000     87.0000      0.0000     64.0000
COD             28.0000      4.0000      4.0000     42.0000     14.0000      4.0000      0.0000     14.0000
COND           280.0000    350.0000    360.0000    400.0000    480.0000    580.0000      0.0000    570.0000
TDS            190.0000    220.0000    280.0000    320.0000    260.0000    340.0000      0.0000    340.0000
TSS           1900.0000    150.0000   2300.0000  11000.0000    110.0000     72.0000      0.0000      8.0000
SULFATE         34.0000     43.0000      6.0000     59.0000     40.0000     28.0000      0.0000     18.0000
ARSENIC      <     .0020       .0050 <     .0040       .0090       .0020 <     .0020       .0020 <     .0020
BORON             .4000       .2900       .2600       .5300       .4700       .8600      0.0000      1.6000
CALCIUM         36.0000     44.0000     37.0000    110.0000     55.0000     42.0000     40.0000     38.0000
LEAD              .0730       .0350       .0880       .1000       .0870       .0200       .0510 <     .0100
MAGNESIUM       15.0000     10.0000      9.0000     15.0000     14.0000     11.0000     12.0000     14.0000
MERCURY      <     .0002       .0003       .0010       .0002       .0011 <     .0002       .0002 <     .0002
SELENIUM     <     .0020 <     .0100 <     .0010       .0010       .0020 <     .0010       .0030       .0020
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          12.0000     17.0000     15.0000     17.0000     22.0000     46.0000     46.0000     53.0000
TOTAL ELEM     103.4772    134.3403     88.3540    222.7202    101.5621    214.8032     98.0562    208.6142

POND C GROUND WELL 2

WELL DESIG         GWC2        GWC2        GWC2        GWC2        GWC2        GWC2
DATE        790912.0000 791113.0000 800114.0000 800314.0000 800518.0000 800702.0000
REC NO.      15500.0000  14840.0000  14860.0000  16920.0000  17440.0000  18000.0000
PH               7.4000      7.5000      7.2000      7.1000      7.4000      7.8000
ALKALINITY     130.0000    120.0000    110.0000    120.0000    120.0000    120.0000
CHLORIDE       100.0000    110.0000    110.0000    130.0000    140.0000    120.0000
COD              4.0000      7.0000      6.0000      6.0000      7.0000      8.0000
COND           560.0000    580.0000    570.0000    700.0000    750.0000    790.0000
TDS            330.0000    350.0000    370.0000    400.0000    430.0000    400.0000
TSS             91.0000     16.0000     12.0000     21.0000     15.0000      6.0000
SULFATE         24.0000      6.0000     20.0000     23.0000     21.0000     22.0000
ARSENIC           .0070 <     .0020 <     .0020 <     .0020       .0080       .0040
BORON             .5000       .0200       .1200       .3200       .0220       .3000
CALCIUM         51.0000     90.0000     47.0000     45.0000     46.0000     46.0000
LEAD              .0300       .0250       .0120       .0100       .0110       .0100
MAGNESIUM       14.0000     17.0000     12.0000     13.0000     13.0000     13.0000
MERCURY      <     .0002 <     .0002       .0004 <     .0002 <     .0002       .0002
SELENIUM          .0020       .0020       .0030       .0200       .0040       .0040
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          62.0000     65.0000     95.0000     63.0000     76.0000     73.0000
TOTAL ELEM     251.5392    288.0492    284.1374    274.3522    296.0452    274.3182
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POND C GROUND WELL 2--- AEROSPACE ---

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WELL DESIG          GWC2        GWC2        GWC2        GWC2        GWC2        GWC2        GWC2        GWC2
DATE         740904.0000 750428.0000 751103.0000 760315.0000 760503.0000 770505.0000 780309.0000 780316.0000
REC NO.        7360.0000   7380.0000   7400.0000   7420.0000   7440.0000   7460.0000   7480.0000   7500.0000
PH                7.8000      7.3500      7.2000      0.0000      7.8100      7.3100      8.1200      8.2600
ALKALINITY       83.0000    149.0000    101.0000      0.0000    141.0000    126.0000     92.0000     84.0000
CHLORIDE         41.0000     99.0000    195.0000     42.0000     54.0000     98.0000     23.0000      8.4000
COD               0.0000     75.0000     10.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND            290.0000    530.0000    950.0000      0.0000    550.0000    520.0000    270.0000    246.0000
TDS             154.0000    340.0000    672.0000      0.0000    406.0000    324.0000    206.0000    158.0000
TSS               0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE          37.0000     25.0000    150.0000      0.0000    110.0000     83.0000     30.0000     30.0000
ARSENIC            .0050       .0050       .0040      0.0000       .0010 <     .0010       .0330      0.0000
BORON              .4000       .1000      3.3000      0.0000       .5000       .8000 <     .5000 <     .5000
CALCIUM          36.0000     32.0000     48.0000     28.0000     78.0000     44.0000     26.0000     21.0000
LEAD               .0300       .0500       .0200      0.0000       .0100       .0300       .2000      0.0000
MAGNESIUM        13.0000     13.4000     40.0000      0.0000     15.0000     11.9000     11.0000      8.0000
MERCURY            .0006       .0003       .0002      0.0000       .0006 <     .0001       .0016      0.0000
SELENIUM           .0050       .0100       .0040      0.0000       .0520 <     .0006       .0001      0.0000
SULFITE            .1000       .2000       .2000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            0.0000      0.0000     58.0000      0.0000     26.0000     53.0000     15.0000     11.0000
TOTAL ELEM      127.5406    169.8453    494.5282     70.0000    283.5636    290.7317    105.7347     78.9000
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POND D SUPERNATE

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WELL DESIG              PSD           PSD           PSD           PSD           PSD           PSD           PSD           PSD
DATE            750211.0000   750217.0000   750224.0000   750428.0000   750708.0000   750901.0000   751103.0000   760106.0000
REC NO.           7520.0000     7540.0000     7560.0000     7580.0000     7600.0000     7620.0000     7640.0000     7660.0000
PH                   8.5000        8.3000        8.1000        8.0000        8.4000        8.0000        8.3000        7.6000
ALKALINITY          97.0000      120.0000      170.0000       35.0000       40.0000       30.0000       33.0000       30.0000
CHLORIDE           950.0000     1100.0000      670.0000      260.0000      200.0000      200.0000       90.0000       32.0000
COD                 11.0000       19.0000       14.0000       16.0000       31.0000       39.0000       36.0000        5.0000
COND              4000.0000     5600.0000     3700.0000     1900.0000     2700.0000     3300.0000     2500.0000     1000.0000
TDS               3400.0000     4400.0000     3000.0000     1700.0000     2900.0000     3500.0000     2600.0000     1000.0000
TSS               2900.0000        8.0000       90.0000        6.0000        7.0000       11.0000       14.0000       10.0000
SULFATE           1100.0000     2000.0000      950.0000      750.0000      130.0000     2600.0000     1200.0000      660.0000
ARSENIC               .2400         .3000         .1200         .0050         .0350         .4700         .5000   <     .0050
BORON               49.0000       64.0000       35.0000       11.0000       10.0000       16.0000       11.0000        8.0000
CALCIUM            830.0000     1000.0000      970.0000      360.0000      650.0000     1200.0000      710.0000      360.0000
LEAD                  .0270   <     .0100         .0120   <     .0100   <     .0100         .0230   <     .0100         .0100
MAGNESIUM          170.0000      200.0000      180.0000       34.0000       17.0000       22.0000       36.0000       14.0000
MERCURY       <       .0002   <     .0002   <     .0002   <     .0002         .0016   <     .0002   <     .0002   <     .0002
SELENIUM              .0750         .0600         .0600         .0180   <     .0020   <     .0020   <     .0010   <     .0020
SULFITE              0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM               0.0000        0.0000        0.0000        0.0000       13.0000       20.0000       22.0000        7.0000
TOTAL ELEM        3099.3422     4364.3902     2805.1922     1415.0332     1220.0406     4058.4952     2069.5912     1073.0172
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POND D SUPERNATE

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WELL DESIG              PSD           PSD           PSD           PSD           PSD           PSD           PSD           PSD
DATE            760301.0000   760503.0000   760706.0000   760909.0000   761109.0000   770223.0000   770504.0000   770707.0000
REC NO.           7680.0000     7700.0000     7720.0000     7740.0000     7760.0000     7780.0000     7800.0000     7820.0000
PH                   7.3000        7.8000        7.4000        7.4000        7.1000        7.7000        6.3000        7.1000
ALKALINITY          24.0000       36.0000       42.0000      860.0000       30.0000       83.0000       30.0000       26.0000
CHLORIDE            23.0000       23.0000       50.0000       14.0000       98.0000       26.0000        8.0000       11.0000
COD                  8.0000       35.0000       25.0000       45.0000       17.0000       24.0000       16.0000       24.0000
COND              1000.0000     1600.0000     1100.0000     1000.0000     1900.0000     1600.0000     1100.0000     1600.0000
TDS                960.0000     1600.0000        0.0000        0.0000     2700.0000     2400.0000     1200.0000     1900.0000
TSS                  2.0000       74.0000        4.0000     9200.0000        8.0000       10.0000        5.0000        5.0000
SULFATE            650.0000      850.0000     1300.0000     2000.0000     2100.0000      160.0000      850.0000     1300.0000
ARSENIC               .0250         .0100         .0450         .1600         .0140         .0040         .0250         .0070
BORON                1.0000        1.0000         .7000        1.7000        2.6000        3.4000         .8000         .9400
CALCIUM            340.0000      320.0000      320.0000      470.0000      580.0010      610.0000      340.0000      440.0000
LEAD          <       .0100   <     .0100   <     .0100         .0910   <     .0100   <     .0100   <     .0100   <     .0100
MAGNESIUM           14.0000       14.0000        8.9000       32.0000       41.0000       23.0000        8.9000        8.0000
MERCURY               .0006   <     .0002   <     .0032   <     .0002         .0006         .0006   <     .0002   <     .0002
SELENIUM              .0040   <     .0040   <     .0010         .0020         .0030         .0040   <     .0040         .0030
SULFITE              0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM               7.5000       12.0000        8.0000       13.0000       19.0000       13.0000        7.3000        9.3000
TOTAL ELEM        1035.5396     1220.0242     1679.6592     2530.9732     2832.6276      835.4206     1215.0392     1790.1402
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POND D SUPERNATE

WELL DESIG	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD
DATE	770926.0000	771104.0000	771216.0000	780316.0000	780511.0000	780628.0000	780821.0000	781207.0000
REC NO.	7840.0000	7860.0000	7880.0000	7900.0000	7920.0000	7940.0000	7960.0000	7980.0000
PH	7.3000	7.5000	7.0000	7.3000	7.2000	7.2000	7.2000	7.3000
ALKALINITY	30.0000	33.0000	26.0000	36.0000	40.0000	35.0000	35.0000	34.0000
CHLORIDE	7.0000	7.0000	3.0000	2.0000	2.0000	2.0000	6.0000	2.0000
COD	32.0000	22.0000	9.0000	7.0000	22.0000	37.0000	76.0000	10.0000
COND	1600.0000	1900.0000	620.0000	450.0000	780.0000	1700.0000	2100.0000	510.0000
TDS	1500.0000	1800.0000	450.0000	330.0000	610.0000	1500.0000	2500.0000	230.0000
TSS	7.0000	11.0000	3.0000	3.0000	7.0000	16.0000	11.0000	6.0000
SULFATE	910.0000	1100.0000	280.0000	58.0000	350.0000	1000.0000	1400.0000	210.0000
ARSENIC	.0860	.0330	< .0020	.0040	.0220	.0820	.0160	.0020
BORON	.5400	.7100	.2200	.1200	.1300	.5000	.0600	.1800
CALCIUM	480.0000	710.0000	140.0000	70.0000	170.0000	470.0000	530.0000	79.0000
LEAD	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100
MAGNESIUM	9.4000	12.0000	5.8000	3.7000	6.4000	11.0000	9.9000	4.0000
MERCURY	.0008	< .0002	< .0002	< .0002	.0006	.0003	< .0002	< .0002
SELENIUM	< .0020	.0010	< .0020	< .0020	< .0010	< .0010	.0020	< .0010
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	7.8000	7.4000	4.2000	2.2000	4.2000	6.7000	10.0000	2.0000
TOTAL ELEM	1414.8388	1837.1542	433.2342	136.0362	532.7636	1490.2933	1955.9882	297.1932

POND D SUPERNATE

WELL DESIG	PSD	PSD	PSD	PSD	PSD	PSD	PSD
DATE	790524.0000	790711.0000	790907.0000	791107.0000	800111.0000	800311.0000	800515.0000
REC NO.	8000.0000	16080.0000	16100.0000	14880.0000	14900.0000	17260.0000	17760.0000
PH	7.4000	7.3000	6.8000	7.2000	7.3000	7.1000	7.2000
ALKALINITY	89.0000	35.0000	33.0000	31.0000	42.0000	48.0000	43.0000
CHLORIDE	1.0000	2.0000	3.0000	4.0000	3.0000	4.0000	4.0000
COD	26.0000	26.0000	54.0000	22.0000	8.0000	14.0000	40.0000
COND	460.0000	770.0000	1300.0000	1400.0000	520.0000	670.0000	1000.0000
TDS	350.0000	680.0000	1200.0000	1300.0000	410.0000	510.0000	810.0000
TSS	2.0000	2.0000	11.0000	14.0000	2.0000	7.0000	7.0000
SULFATE	170.0000	430.0000	690.0000	80.0000	310.0000	320.0000	480.0000
ARSENIC	.0140	.0290	.0040	.0070	.0040	.0500	.0100
BORON	.3300	1.5000	.4000	9.0000	.0700	.1500	.1200
CALCIUM	110.0000	97.0000	310.0000	580.0000	130.0000	120.0000	250.0000
LEAD	< .0100	< .0100	.0100	< .0100	< .0100	< .0100	.0020
MAGNESIUM	3.6000	4.0000	5.1000	7.3000	5.3000	6.5000	7.7000
MERCURY	< .0002	< .0002	< .0002	< .0002	.0003	< .0002	< .0002
SELENIUM	.0030	< .0010	< .0010	< .0010	< .0010	< .0010	.0010
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	1.7000	1.8000	3.2000	3.5000	4.3000	4.2000	5.9000
TOTAL ELEM	286.6572	536.3402	1011.7152	683.8182	452.6853	454.9112	747.7332

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POND D SUPERNATE    --- AEROSPACE ---

WELL DESIG          PSD         PSD         PSD         PSD         PSD         PSD         PSD         PSD
DATE        750211.0000 750707.0000 751103.0000 760503.0000 761109.0000 770505.0000 780309.0000 780316.0000
REC NO.       8020.0000   8040.0000   8060.0000   8080.0000   8100.0000   8120.0000   8140.0000   8160.0000
FH               8.2700      7.4800      7.2800      6.9200      7.2300      6.8100      7.3200      7.5700
ALKALINITY      68.0000     45.0000     41.0000     35.0000     46.0000     27.0000      6.0000     23.0000
CHLORIDE      1100.0000    205.0000    225.0000     84.0000    135.0000    110.0000      1.5000      2.2000
COD              0.0000     95.0000     40.0000      0.0000      0.0000      0.0000      0.0000      0.0000
COND          3600.0000   2440.0000   2380.0000   1580.0000   2330.0000   1190.0000     73.0000    311.0000
TDS           3020.0000   3320.0000   2530.0000   1620.0000   2514.0000   1118.0000     36.0000    258.0000
TSS              0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE        950.0000   1700.0000   1625.0000   1000.0000   1475.0000    775.0000     12.0000    135.0000
ARSENIC           .2800       .0900       .0040       .0340       .0160       .0140 <     .0040      0.0000
BORON           44.0000      8.0000      7.8000      1.5000      4.0000      1.2000 <     .5000       .8000
CALCIUM        560.0000    460.0000    600.0000    400.0000    650.0000    330.0000     11.0000     46.0000
LEAD              .2100       .0500 <     .0100 <     .0100       .0350       .0600       .2000      0.0000
MAGNESIUM      152.0000     15.5000     37.0000     19.0000     30.0000      7.0000      1.1000      4.1000
MERCURY          0.0000      0.0000       .0002       .0013 <     .0001 <     .0001       .0006      0.0000
SELENIUM          .0620       .0020       .0020       .0170 <     .0006       .0027       .0001      0.0000
SULFITE          1.5000       .3600       .1000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           0.0000      0.0000     26.0000    120.0000     22.0000      7.8000      1.0000      2.5000
TOTAL ELEM    2808.0520   2389.0020   2520.9162   1624.5623   2316.0517   1231.0768     27.3047    190.6000
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POND D SUPERNATE    --- AEROSPACE ---

WELL DESIG          PSD
DATE        791107.0000
REC NO.      16380.0000
PH               6.3200
ALKALINITY      27.8000
CHLORIDE         1.5000
COD              0.0000
COND          1220.0000
TDS           1286.0000
TSS              0.0000
SULFATE        750.0000
ARSENIC           .0200
BORON       <     .5000
CALCIUM        230.0000
LEAD              .0300
MAGNESIUM        8.2000
MERCURY     <     .0002
SELENIUM          .0020
SULFITE          0.0000
SODIUM           4.4000
TOTAL ELEM     994.6522
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POND D LEACHATE

WELL DESIG          LWD            LWD            LWD            LWD            LWD            LWD            LWD            LWD
DATE            750211.0000    750217.0000    750228.0000    750428.0000    750707.0000    750901.0000    751103.0000    760106.0000
REC NO.           8180.0000      8200.0000      8220.0000      8240.0000      8260.0000      8280.0000      8300.0000      8320.0000
PH                   9.0000         9.1000         9.0000         8.7000         8.3000         7.7000         6.9000         9.0000
ALKALINITY         160.0000       140.0000       120.0000       120.0000       110.0000        54.0000        31.0000        68.0000
CHLORIDE          1400.0000       310.0000       560.0000      1500.0000       810.0000       680.0000       450.0000       260.0000
COD                 13.0000        15.0000         0.0000        27.0000        20.0000        21.0000        36.0000       180.0000
COND              5000.0000      4300.0000      3200.0000      4400.0000      4600.0000      4200.0000      3500.0000      2600.0000
TDS               4200.0000      3700.0000      3500.0000      4000.0000      4500.0000      4000.0000      3400.0000      2800.0000
TSS                  0.0000         0.0000        34.0000        20.0000      1400.0000       100.0000       120.0000       220.0000
SULFATE           1200.0000         0.0000      1200.0000      1600.0000      1100.0000      1700.0000      1200.0000      1200.0000
ARSENIC               .0880          .1100          .0700          .1600          .0080         1.0000          .0400          .1700
BORON               58.0000        48.0000        39.0000        47.0000        55.0000        54.0000        31.0000        16.0000
CALCIUM           1200.0000       990.0000      1200.0000      1100.0000       940.0000      1200.0000       940.0000      1000.0000
LEAD                  .0150          .0370          .0280          .0300          .1800          .0210  <       .0100          .0700
MAGNESIUM           66.0000        58.0000        84.0000       140.0000       180.0000       170.0000        79.0000        26.0000
MERCURY               .0007          .0035          .0013          .0008          .0075  <       .0002  <       .0002          .0004
SELENIUM      <       .0020          .1000          .0160          .0080          .0480          .0140          .0060  <       .0040
SULFITE              0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
SODIUM               0.0000         0.0000         0.0000         0.0000        38.0000        30.0000        14.0000         8.7000
TOTAL ELEM        3924.1057      1406.2505      3083.1153      4387.1988      3123.2435      3835.0352      2714.0562      2510.9444
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POND D LEACHATE

WELL DESIG          LWD            LWD            LWD            LWD            LWD            LWD            LWD            LWD
DATE            760301.0000    760503.0000    760706.0000    760909.0000    761109.0000    770215.0000    770302.0000    770504.0000
REC NO.           8340.0000      8360.0000      8380.0000      8400.0000      8420.0000      8440.0000      8460.0000      8480.0000
PH                   8.8000         7.6000         7.4000         6.0000         4.6000         6.8000         6.2000         4.8000
ALKALINITY          48.0000        28.0000        54.0000        11.0000         1.0000        11.0000         8.0000         4.0000
CHLORIDE            56.0000       180.0000       190.0000       100.0000       100.0000       100.0000       100.0000        52.0000
COD                 82.0000        40.0000        54.0000        32.0000        46.0000         9.0000        58.0000        36.0000
COND              2500.0000      2500.0000      2400.0000      2100.0000      2000.0000      2200.0000      2000.0000      2000.0000
TDS               2600.0000      2600.0000      3000.0000      2600.0000      2700.0000      2600.0000      2600.0000      2600.0000
TSS                 23.0000         7.0000      2400.0000      4200.0000        10.0000        27.0000        46.0000       100.0000
SULFATE           1100.0000      1200.0000      1500.0000      2100.0000      2300.0000      1800.0000      1800.0000      1900.0000
ARSENIC               .4800          .1200          .4800          .1700          .4500          .2400          .0700          .7000
BORON                9.5000         8.3000        13.0000         7.4000         8.0000         4.6000        16.0000         4.8000
CALCIUM           1000.0000       470.0000       640.0000       350.0000       640.0000       700.0000       570.0000       660.0000
LEAD                  .0750          .0100          .0210          .0220  <       .0100  <       .0100          .0100          .0120
MAGNESIUM           18.0000        14.0000        29.0000        20.0000        22.0000        19.0000        15.0000        18.0000
MERCURY               .0002  <       .0002          .0008  <       .0002  <       .0002  <       .0002  <       .0002          .0006
SELENIUM      <       .0040          .0080          .0320          .0020          .0130          .0100          .0140          .0210
SULFITE              0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
SODIUM              11.0000        17.0000        22.0000        85.0000        10.0000        12.0000        13.0000        11.0000
TOTAL ELEM        2195.0592      1889.4382      2394.5338      2662.5942      3080.4732      2635.8602      2514.0942      2646.5336
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POND D LEACHATE

WELL DESIG          LWD         LWD         LWD         LWD         LWD         LWD         LWD         LWD 
DATE         770713.0000 770926.0000 771104.0000 771220.0000 780316.0000 780511.0000 780628.0000 780821.0000
REC NO.        8500.0000   8520.0000   8540.0000   8560.0000   8580.0000   8600.0000   8620.0000   8640.0000
PH                5.4000      5.4000      9.4000      4.7000      4.0000      4.1000      6.3000      4.2000
ALKALINITY        5.0000      6.0000     75.0000      1.0000      0.0000      0.0000      9.0000      0.0000
CHLORIDE         44.0000     24.0000     69.0000     16.0000     14.0000     11.0000      9.0000      6.0000
COD             120.0000    320.0000     34.0000     42.0000     44.0000      5.0000     19.0000     23.0000
COND           2300.0000   2900.0000   2600.0000   2500.0000   2300.0000   2300.0000   2400.0000   2500.0000
TDS            3300.0000   2800.0000   2600.0000   2500.0000   2300.0000   2300.0000   2300.0000   2500.0000
TSS            1400.0000   6500.0000   4200.0000   4400.0000   1600.0000    130.0000    330.0000     77.0000
SULFATE        2100.0000   1800.0000   1800.0000   1500.0000   1200.0000   1500.0000   1500.0000      0.0000
ARSENIC            .1600       .2200       .0140       .6200       .0880       .4400       .0620       .0550
BORON             4.6000      4.0000      3.3000      2.2000      1.2000      1.3000       .8800      3.4000
CALCIUM         630.0000    850.0000    990.0000    710.0000    680.0000    580.0000    810.0000    730.0000
LEAD         <     .0100       .0150       .0260       .0220 <     .0100       .0500       .0540 <     .0100
MAGNESIUM        22.0000     26.0000     12.0000      8.8000      7.1000      7.1000      6.3000      5.8000
MERCURY      <     .0002       .0019       .0006       .0008 <     .0002       .0010       .0012       .0002
SELENIUM           .0140       .1100       .0300       .0060       .0020       .0030 <     .0010       .0090
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           16.0000     12.0000      8.5000      9.3000      7.7000      8.1000      8.3000     11.0000
TOTAL ELEM     2816.7842   2716.3469   2882.8706   2246.9488   1910.1002   2107.9940   2334.5982    756.2742
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POND D LEACHATE

WELL DESIG          LWD         LWD         LWD         LWD         LWD         LWD         LWD         LWD 
DATE         781206.0000 790309.0000 790521.0000 790716.0000 790912.0000 791107.0000 800114.0000 800311.0000
REC NO.        8660.0000   8680.0000   8700.0000  16000.0000  16020.0000  14920.0000  14940.0000  17200.0000
PH                9.3000      5.7000      5.8000      4.0000      3.6000      7.0000      6.6000      4.0000
ALKALINITY      150.0000      8.0000      5.0000      0.0000      0.0000     36.0000     15.0000      0.0000
CHLORIDE         20.0000      8.0000      5.0000     60.0000      6.0000      6.0000     70.0000     12.0000
COD             350.0000     82.0000     26.0000     50.0000     19.0000    180.0000     77.0000    110.0000
COND           2700.0000   2400.0000   2300.0000   2300.0000   2400.0000   2400.0000   2400.0000   2400.0000
TDS            2500.0000   2300.0000   2300.0000   2500.0000   2700.0000   2600.0000   2400.0000   1900.0000
TSS            1900.0000    470.0000     56.0000    950.0000     86.0000    640.0000     40.0000     93.0000
SULFATE        1600.0000   1600.0000   1300.0000   1600.0000   2100.0000   1800.0000   1500.0000   1400.0000
ARSENIC            .0250       .0340       .0280       .0870       .0860       .0680       .1100       .1100
BORON             1.6000      2.5000      5.2000       .2000       .7700      1.8000      1.0000      1.5000
CALCIUM         920.0000    650.0000    780.0000    670.0000    710.0000    580.0000    700.0000    670.0000
LEAD               .0580 <     .0100 <     .0100 <     .0100 <     .0100       .0290 <     .0100       .0130
MAGNESIUM         6.4000      5.9000      7.1000      5.8000      4.9000      5.4000      4.3000      5.7000
MERCURY      <     .0002       .0004 <     .0002 <     .0002 <     .0002       .0005       .0004 <     .0002
SELENIUM           .0050       .0070       .0030       .0080       .0070       .0170       .0050       .0030
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            7.4000      9.6000      7.1000      4.9000      5.1000      6.0000      4.2000      3.9000
TOTAL ELEM     2555.4882   2276.0514   2104.4412   2341.0052   2826.8732   2399.3145   2279.6254   2093.2262
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POND D LEACHATE

WELL DESIG          LWD
DATE        800515.0000
REC NO.      17720.0000
PH               3.9000
ALKALINITY       0.0000
CHLORIDE         1.0000
COD              0.0000
COND          2200.0000
TDS           2300.0000
TSS             51.0000
SULFATE       1400.0000
ARSENIC           .1500
BORON            1.0400
CALCIUM        720.0000
LEAD              .0600
MAGNESIUM        5.8000
MERCURY     <     .0002
SELENIUM          .0020
SULFITE          0.0000
SODIUM           3.3000
TOTAL ELEM    2131.3522
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POND D LEACHATE     --- AEROSPACE ---

WELL DESIG          LWD           LWD           LWD           LWD           LWD           LWD           LWD           LWD
DATE        750211.0000   750707.0000   751103.0000   760121.0000   760503.0000   761109.0000   770302.0000   770504.0000
REC NO.       8720.0000     8740.0000     8760.0000     8780.0000     8800.0000     8820.0000     8840.0000     8860.0000
PH               8.9600        8.0800        4.5900        7.7900        5.6500        2.6000        2.8000        5.3200
ALKALINITY      53.0000      130.0000        0.0000        1.0000        3.0000        0.0000        0.0000        2.0000
CHLORIDE      1300.0000      940.0000      490.0000      970.0000      240.0000      170.0000      155.0000      180.0000
COD              0.0000       95.0000       25.0000       50.0000        0.0000        0.0000        0.0000        0.0000
COND          5000.0000     4270.0000      570.0000     2740.0000     2380.0000     2670.0000     2520.0000     2360.0000
TDS           3960.0000     4240.0000     3370.0000     2970.0000     2560.0000     2436.0000     2514.0000     2402.0000
TSS              0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SULFATE       1425.0000     1600.0000     1750.0000     1375.0000     1400.0000     1450.0000     1725.0000     1625.0000
ARSENIC           .0300         .2100         .0120         .3400         .9050         .3200         .6700        5.3000
BORON           52.0000       58.0000       32.0000        1.3000        6.5000        8.8000        6.0000        4.7500
CALCIUM        960.0000      900.0000      760.0000      675.0000      600.0000      650.0000      630.0000      660.0000
LEAD              .2600         .0500   <     .0100   <     .0100   <     .0100         .0250         .0650         .2300
MAGNESIUM       63.0000       18.0000       99.0000       37.0000       18.0000       14.0000       13.0000       13.9000
MERCURY          0.0000         .0002         .0005         .0012         .0013   <     .0001   <     .0001         .0003
SELENIUM          .0160         .0550         .0060         .0040         .0650         .0047   <     .0006         .0013
SULFITE          6.1000         .4000        1.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           0.0000        0.0000       14.0000       17.0000       17.0000       10.0000       10.0000       10.2000
TOTAL ELEM    3806.4060     3516.7152     3146.0285     3075.6552     2282.4813     2303.1498     2539.7357     2499.3816
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POND D LEACHATE      --- AEROSPACE ---

WELL DESIG         LWD          LWD          LWD          LWD
DATE        780309.0000  780316.0000  790306.0000  791107.0000
REC NO.       8880.0000    8900.0000    8920.0000   16400.0000
PH               4.1800       4.2800       7.2000       6.2300
ALKALINITY       0.0000       0.0000       1.0000      43.0000
CHLORIDE        15.0000       9.0000      20.0000      17.0000
COD              0.0000       0.0000       0.0000       0.0000
COND          2070.0000    2060.0000    1960.0000    1980.0000
TDS           2164.0000    2277.0000    2178.0000    2459.0000
TSS              0.0000       0.0000       0.0000       0.0000
SULFATE       1400.0000    1475.0000    1575.0000    1400.0000
ARSENIC           .2500       0.0000 <      .0100        .0090
BORON            2.6000       2.2000        .7000       1.5000
CALCIUM        460.0000     500.0000     460.0000     450.0000
LEAD              .1400       9.8000 <      .1000        .0600
MAGNESIUM        8.8000       0.0000       5.0000       4.3000
MERCURY           .0002       0.0000 <      .0005        .0010
SELENIUM          .0003       0.0000        .0120        .0080
SULFITE          0.0000       0.0000       0.0000       0.0000
SODIUM           7.0000       9.5000       8.8000       4.6000
TOTAL ELEM    1893.7905    2005.5000    2069.6225    1877.4780
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POND D GROUND WELL 1

WELL DESIG          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1
DATE         740722.0000   740729.0000   740805.0000   740903.0000   741007.0000   741028.0000   741104.0000   741111.0000
REC NO.        8940.0000     8960.0000     8980.0000     9000.0000     9020.0000     9040.0000     9060.0000     9080.0000
PH                7.1000        6.6000        6.7000        7.0000        6.8000        6.9000        7.3000        7.8000
ALKALINITY       72.0000      110.0000      140.0000      140.0000       60.0000       52.0000      100.0000       52.0000
CHLORIDE         20.0000       50.0000       72.0000      110.0000       89.0000      170.0000       17.0000       12.0000
COD               0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
COND            220.0000      420.0000        0.0000        0.0000        0.0000      670.0000      670.0000      600.0000
TDS             210.0000      260.0000      330.0000      410.0000      330.0000      420.0000      510.0000        0.0000
TSS            2100.0000      100.0000       15.0000        0.0000       64.0000     6600.0000     2200.0000        0.0000
SULFATE          16.0000       22.0000       14.0000       12.0000       40.0000       85.0000      160.0000      340.0000
ARSENIC            .0150         .0080         .0060         .0050         .0050  <      .0050  <      .0050  <      .0050
BORON             0.0000  <      .1000  <      .1000  <      .1000  <      .1000  <      .1000         .2500  <      .1000
CALCIUM           0.0000       27.0000       30.0000       29.0000       18.0000       17.0000        0.0000        0.0000
LEAD              0.0000         .0790         .0490        0.0000         .0100  <      .0100        0.0000        0.0000
MAGNESIUM         0.0000       11.0000       11.0000       13.0000        6.8000        7.3000        0.0000        0.0000
MERCURY     <      .0002         .0010  <      .0002  <      .0002  <      .0002  <      .0002        0.0000        0.0000
SELENIUM    <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
TOTAL ELEM       36.0172      110.1900      127.1572      164.1072      153.9172      279.4172      177.2570      352.1070


POND D GROUND WELL 1

WELL DESIG          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1
DATE         741209.0000   750211.0000   750217.0000   750224.0000   750428.0000   750708.0000   750901.0000   751103.0000
REC NO.        9100.0000     9120.0000     9140.0000     9160.0000     9180.0000     9200.0000     9220.0000     9240.0000
PH                0.0000        6.9000        6.7000        6.7000        6.9000        6.9000        7.0000        7.1000
ALKALINITY        0.0000      140.0000      150.0000      140.0000      150.0000      140.0000      140.0000       54.0000
CHLORIDE          0.0000      150.0000      100.0000      100.0000      240.0000      160.0000      320.0000      320.0000
COD               0.0000       14.0000       24.0000       16.0000       14.0000       22.0000       13.0000        0.0000
COND              0.0000      700.0000      660.0000      680.0000      690.0000      890.0000     1400.0000     1200.0000
TDS               0.0000      420.0000      380.0000      380.0000      410.0000      740.0000      870.0000      800.0000
TSS               0.0000        0.0000        0.0000      190.0000       12.0000      720.0000      340.0000      170.0000
SULFATE           0.0000       24.0000        7.0000        9.0000       38.0000       74.0000      320.0000      130.0000
ARSENIC     <      .0050  <      .0050  <      .0050  <      .0050  <      .0050  <      .0050         .0050  <      .0050
BORON       <      .1000        0.0000  <      .1000         .1300         .1600         .2200         .6000         .2400
CALCIUM           0.0000       66.0000       38.0000       37.0000        0.0000       53.0000       99.0000      160.0000
LEAD              0.0000         .0160         .0320         .0900        0.0000         .2600         .0190         .3400
MAGNESIUM         0.0000        9.1000        8.9000       16.0000        0.0000       22.0000       29.0000       61.0000
MERCURY           0.0000  <      .0002         .0002         .0020         .0005         .0011  <      .0002  <      .0002
SELENIUM    <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0020  <      .0010
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            0.0000        0.0000        0.0000        0.0000        0.0000      110.0000      120.0000      160.0000
TOTAL ELEM         .1070      249.1232      154.0392      162.2290      278.1675      419.4881      888.6262      831.5862
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POND D GROUND WELL 1

WELL DESIG          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1
DATE         760315.0000   760503.0000   760712.0000   760914.0000   770504.0000   771216.0000   780316.0000   780511.0000
REC NO.        9260.0000     9280.0000     9300.0000     9320.0000     9340.0000     9360.0000     9380.0000     9400.0000
PH                6.5000        7.1000        7.3000        6.7000        6.5000        6.6000        7.0000        7.1000
ALKALINITY       61.0000       86.0000      110.0000       82.0000       75.0000       53.0000       76.0000       98.0000
CHLORIDE          0.0000      240.0000      350.0000      450.0000      310.0000      280.0000      300.0000      240.0000
COD              13.0000       27.0000       34.0000       42.0000       38.0000      130.0000       60.0000       23.0000
COND           1300.0000     1100.0000     1300.0000     1500.0000     1400.0000     1300.0000     1600.0000     1300.0000
TDS             810.0000      650.0000      830.0000     1100.0000      750.0000      770.0000      880.0000      890.0000
TSS             490.0000      400.0000      140.0000     1300.0000     1300.0000     6700.0000      210.0000     5600.0000
SULFATE          20.0000       40.0000       40.0000      110.0000       60.0000      100.0000      150.0000       48.0000
ARSENIC     <      .0100  <      .0050  <      .0050  <      .0050         .0380         .0090  <      .0020         .1200
BORON              .0700         .1300         .1700         .1900         .3000         .2400         .2000         .1100
CALCIUM         160.0000       40.0000       82.0000       77.0000       64.0000       49.0000       90.0000       88.0000
LEAD               .3400         .0120        0.0000         .1600         .0860         .2500  <      .0100         .4200
MAGNESIUM        29.0000       15.0000       27.0000       33.0000       20.0000       26.0000       25.0000       35.0000
MERCURY            .0002  <      .0002         .0002  <      .0002         .0028         .0006  <      .0002         .0041
SELENIUM           .0020  <      .0040         .0020  <      .0010  <      .0040         .0030  <      .0020  <      .0010
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM          190.0000      140.0000      180.0000       18.0000      150.0000      170.0000      210.0000      170.0000
TOTAL ELEM      399.4222      475.1512      679.1772      688.3562      604.4308      625.5026      775.2142      581.6551
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POND D GROUND WELL 1

WELL DESIG          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1          GWD1
DATE         780628.0000   780821.0000   790122.0000   790521.0000   790711.0000   790912.0000   791108.0000   800115.0000
REC NO.        9420.0000     9440.0000     9460.0000     9480.0000    15520.0000    15540.0000    14960.0000    14980.0000
PH                7.7000        6.8000        6.6000        7.0000        7.2000        7.0000        6.7000        6.7000
ALKALINITY      120.0000      110.0000       76.0000       91.0000       96.0000      110.0000      120.0000      130.0000
CHLORIDE        290.0000      300.0000      260.0000      250.0000       30.0000      250.0000      220.0000      190.0000
COD              18.0000       44.0000       17.0000       15.0000       25.0000       14.0000       11.0000       12.0000
COND           1600.0000     1600.0000      150.0000     1600.0000     1700.0000     1700.0000     1700.0000     1600.0000
TDS             990.0000     1100.0000      760.0000      990.0000     1100.0000     1300.0000     1200.0000     1200.0000
TSS           11000.0000    11000.0000       63.0000       31.0000       77.0000      640.0000     1100.0000       30.0000
SULFATE         290.0000      340.0000      160.0000      440.0000      360.0000      500.0000      900.0000      580.0000
ARSENIC     <      .0040         .0150         .0060         .0020  <      .0020         .0240         .0050         .0030
BORON              .5300        1.3000         .6300        2.4000         .2200         .1500        1.7000        2.2000
CALCIUM         110.0000      110.0000       76.0000      120.0000       73.0000      120.0000      210.0000      150.0000
LEAD               .1600         .1200         .1200         .0230         .0370  <      .0100         .2100         .0580
MAGNESIUM        40.0000       46.0000       28.0000       36.0000       41.0000       40.0000       62.0000       52.0000
MERCURY            .0012  <      .0002  <      .0002         .0002  <      .0002  <      .0002  <      .0002  <      .0002
SELENIUM           .0010         .0030         .0020         .0090         .0020         .0040         .0020         .0030
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM          200.0000      180.0000      170.0000      180.0000      180.0000      150.0000      180.0000      230.0000
TOTAL ELEM      930.6962      977.4382      694.7582     1028.4342      684.2612     1060.1882     1573.9172     1204.2642
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POND D GROUND WELL 1

WELL DESIG          GWD1        GWD1        GWD1
DATE         800314.0000 800518.0000 800702.0000
REC NO.       16940.0000  17460.0000  18020.0000
PH                7.4000      7.3000      7.4000
ALKALINITY      110.0000    100.0000     96.0000
CHLORIDE        180.0000    220.0000    170.0000
COD              15.0000     14.0000     14.0000
COND           2100.0000   2200.0000   2100.0000
TDS            1500.0000   1400.0000   1500.0000
TSS              59.0000     14.0000      8.0000
SULFATE         830.0000    680.0000    780.0000
ARSENIC            .0020 <     .0020       .0020
BORON             2.0000      2.0000      2.7000
CALCIUM         140.0000    200.0000    180.0000
LEAD               .0320       .0290       .0110
MAGNESIUM        62.0000     72.0000     67.0000
MERCURY      <     .0002 <     .0002 <     .0002
SELENIUM           .0300       .0030       .0020
SULFITE           0.0000      0.0000      0.0000
SODIUM          200.0000    210.0000    200.0000
TOTAL ELEM     1414.0642   1334.0342   1399.7152


POND D GROUND WELL 1--- AEROSPACE ---

WELL DESIG          GWD1        GWD1        GWD1        GWD1        GWD1        GWD1        GWD1        GWD1
DATE         741007.0000 741028.0000 750211.0000 751103.0000 760503.0000 770405.0000 780309.0000 780316.0000
REC NO.        9500.0000   9520.0000   9540.0000   9560.0000   9580.0000   9600.0000   9620.0000   9640.0000
PH                7.7000      7.4800      7.4900      7.0100      7.2700      7.1300      8.0400      7.7700
ALKALINITY       76.0000      0.0000    138.0000     60.0000     86.0000     68.0000     72.0000     46.0000
CHLORIDE        170.0000    210.0000    135.0000    440.0000    500.0000    360.0000    730.0000    600.0000
COD              25.0000      0.0000     40.0000     25.0000      0.0000      0.0000      0.0000      0.0000
COND            380.0000    660.0000    640.0000      1.1000      1.1000   1140.0000   1520.0000   1560.0000
TDS             696.0000    304.0000    372.0000    690.0000    642.0000    646.0000   1008.0000   1020.0000
TSS               0.0000   1010.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE          29.0000     29.0000     10.0000     15.0000     18.0000     50.0000    280.0000    210.0000
ARSENIC            .0040       .0040       .0050       .0060       .0130 <     .0010       .0600      0.0000
BORON              .1000       .2000      1.0000       .9000       .5000      1.0000 <     .5000 <     .5000
CALCIUM          10.0000     20.0000     28.0000     32.0000     56.0000     55.0000     80.0000     80.0000
LEAD               .0500       .0130       .0400 <     .0100 <     .0100       .0350       .2000      0.0000
MAGNESIUM         7.4000     11.2000     17.0000     25.0000     26.0000     18.9000     40.0000     37.0000
MERCURY            .0010       .0013       .0003       .0003       .0006 <     .0001       .0026      0.0000
SELENIUM           .0020       .0080       .0050       .0040       .0520 <     .0006       .0004      0.0000
SULFITE          28.0000       .1000       .6000       .1000      0.0000      0.0000      0.0000      0.0000
SODIUM            0.0000      0.0000      0.0000    149.0000    148.0000    142.0000    210.0000    225.0000
TOTAL ELEM      244.5570    270.5263    191.6503    662.0203    748.5756    626.9367   1260.7630   1152.5000
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POND D GROUND WELL 1--- AEROSPACE ---

WELL DESIG         GWD1
DATE        790314.0000
REC NO.       9660.0000
PH               7.1000
ALKALINITY      60.4000
CHLORIDE       390.0000
COD              0.0000
COND          1100.0000
TDS            684.0000
TSS              0.0000
SULFATE        135.0000
ARSENIC           .0100
BORON             .8000
CALCIUM         90.0000
LEAD        <     .0900
MAGNESIUM       29.9000
MERCURY           .0015
SELENIUM          .0190
SULFITE          0.0000
SODIUM         140.0000
TOTAL ELEM     785.8205
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POND E SUPERNATE


WELL DESIG           PSE          PSE          PSE          PSE          PSE          PSE          PSE          PSE
DATE         750211.0000  750428.0000  750708.0000  750901.0000  751103.0000  760106.0000  760301.0000  760503.0000
REC NO.        9680.0000    9700.0000    9720.0000    9740.0000    9760.0000    9780.0000    9800.0000    9820.0000
PH               11.9000      10.2000       7.5000       7.9000       7.9000       7.6000       8.0000       7.6000
ALKALINITY      410.0000      34.0000      27.0000      26.0000      27.0000      32.0000      22.0000      32.0000
CHLORIDE        170.0000     110.0000     100.0000      68.0000     110.0000      40.0000      68.0000      42.0000
COD               6.0000       9.0000       7.0000      15.0000      14.0000       8.0000      14.0000      27.0000
COND           2800.0000    1600.0000    2000.0000    2500.0000    2600.0000    1200.0000    2300.0000    2400.0000
TDS            1300.0000    1200.0000    1700.0000    2200.0000    2400.0000    1200.0000    2200.0000    2300.0000
TSS               6.0000      12.0000      19.0000      46.0000     120.0000      26.0000       5.0000       7.0000
SULFATE         220.0000     390.0000     840.0000    1400.0000    1100.0000     850.0000    1100.0000    1400.0000
ARSENIC      <     .0050 <     .0050        .0100        .0100        .0050 <     .0050        .0050 <     .0050
BORON               .1100        .3300        .6600        .8000        .2500       0.0000        .2200        .2900
CALCIUM          19.0000     170.0000     260.0000     400.0000     360.0000     400.0000     500.0000     410.0000
LEAD         <     .0100        .0360        .0110        .0170        .1000 <     .0100 <     .0100 <     .0100
MAGNESIUM          .3000       1.0000       3.7000       3.3000       4.1000       4.5000       2.1000       5.8000
MERCURY            .0008 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM     <     .0020        .0030 <     .0020 <     .0020 <     .0010        .0040 <     .0040 <     .0020
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM            0.0000       0.0000     140.0000     180.0000     190.0000      56.0000     170.0000     110.0000
TOTAL ELEM      409.4278     671.3742    1344.3832    2072.1292    1764.4562    1350.5192    1840.3392    1966.1072
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POND E SUPERNATE


WELL DESIG           PSE          PSE          PSE          PSE          PSE          PSE          PSE
DATE         760706.0000  760914.0000  761109.0000  770223.0000  770505.0000  770707.0000  770926.0000
REC NO.        9840.0000    9860.0000    9880.0000    9900.0000    9920.0000    9940.0000    9960.0000
PH                7.3000       8.0000       8.7000       7.8000       6.8000       7.0000       7.3000
ALKALINITY       36.0000      39.0000      22.0000      34.0000      29.0000      32.0000      33.0000
CHLORIDE         22.0000      43.0000      90.0000      39.0000      16.0000      16.0000      42.0000
COD              13.0000      33.0000      14.0000      15.0000      14.0000      16.0000      34.0000
COND           1300.0000    2200.0000    2000.0000    1200.0000    1100.0000    1000.0000    1300.0000
TDS            1300.0000    2700.0000    2400.0000    1100.0000    1200.0000    1000.0000    1100.0000
TSS              14.0000      62.0000       6.0000       5.0000       6.0000      77.0000      38.0000
SULFATE         770.0000    2200.0000    1500.0000     870.0000     680.0000       0.0000     330.0000
ARSENIC      <     .0050 <     .0050 <     .0020        .0040        .0090        .0050        .0040
BORON               .5900       1.2000        .6900        .5700        .7000        .6400        .7200
CALCIUM         300.0000     530.0000     660.0000     280.0000     270.0000     260.0000     220.0000
LEAD               .0410        .0320 <     .0100 <     .0100 <     .0100 <     .0100        .0120
MAGNESIUM         3.0000       4.9000       6.8000       4.0000       4.0000       3.8000       3.2000
MERCURY      <     .0002        .0004 <     .0002        .0002 <     .0002 <     .0002 <     .0002
SELENIUM           .0010        .0010        .0030        .0020        .0030        .0020 <     .0010
SULFITE           0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM           38.0000      59.0000     110.0000      48.0000      26.0000      21.0000      32.0000
TOTAL ELEM     1133.6372    2838.1384    2367.5052    1241.5862     996.7222     301.4572     627.9372
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POND E SUPERNATE    --- AEROSPACE ---


WELL DESIG          PSE         PSE         PSE         PSE         PSE         PSE
DATE        750211.0000 750707.0000 751103.0000 760503.0000 761109.0000 770505.0000
REC NO.       9980.0000  10000.0000  10020.0000  10040.0000  10060.0000  10080.0000
PH              11.7900      6.9500      7.2100      6.8600      7.1100      6.8000
ALKALINITY     536.0000     28.0000     74.0000     32.0000     20.0000     26.0000
CHLORIDE       365.0000    245.0000    170.0000    110.0000    175.0000    110.0000
COD             20.0000     60.0000     10.0000      0.0000      0.0000      0.0000
COND          2900.0000   1660.0000   2380.0000   2270.0000   2370.0000   1220.0000
TDS           1440.0000   1720.0000   2380.0000   2310.0000   2364.0000   1102.0000
TSS              0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE        250.0000   1000.0000   1375.0000   1400.0000   1425.0000    700.0000
ARSENIC           .0040       .0040       .0060       .0230       .0160       .0030
BORON             .4000       .7000       .8000      1.5000      2.0000      1.9500
CALCIUM         24.0000    260.0000     80.0000    450.0000    500.0000    270.0000
LEAD              .0500       .0500 <     .0200 <     .0100       .0350       .0750
MAGNESIUM       30.0000      3.3000      5.0000      7.0000      5.0000      3.2000
MERCURY          0.0000       .0001       .0002       .0007 <     .0001       .0004
SELENIUM          .0013       .0190       .0160       .0430 <     .0006       .0033
SULFITE           .2000       .1000       .4000      0.0000      0.0000      0.0000
SODIUM           0.0000    190.0000    195.0000    114.0000    102.0000     25.0000
TOTAL ELEM     669.7353   1699.2531   1826.2422   2082.5767   2209.0517   1110.2317
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POND E LEACHATE

WELL DESIG	LWE	LWE	LWE	LWE	LWE	LWE	LWE	LWE
DATE	750211.0000	750428.0000	750707.0000	750901.0000	751103.0000	760106.0000	760301.0000	760503.0000
REC NO.	10100.0000	10120.0000	10140.0000	10160.0000	10180.0000	10200.0000	10220.0000	10240.0000
PH	7.9000	11.1000	11.2000	10.7000	10.5000	9.5000	9.9000	8.2000
ALKALINITY	120.0000	490.0000	700.0000	550.0000	300.0000	190.0000	110.0000	110.0000
CHLORIDE	1000.0000	0.0000	650.0000	25.0000	320.0000	370.0000	490.0000	420.0000
COD	56.0000	320.0000	180.0000	150.0000	240.0000	110.0000	0.0000	110.0000
COND	4800.0000	0.0000	4600.0000	4000.0000	3700.0000	3300.0000	3700.0000	3800.0000
TDS	2400.0000	3400.0000	2900.0000	2700.0000	2700.0000	2700.0000	2800.0000	2400.0000
TSS	0.0000	14.0000	9300.0000	7600.0000	14.0000	920.0000	92.0000	1200.0000
SULFATE	300.0000	670.0000	370.0000	1100.0000	850.0000	1300.0000	1100.0000	1000.0000
ARSENIC	.0270	.1400	.1100	.0550	.0960	.0550	.0650	0.0000
BORON	.6000	.1400	< .1000	.8000	.3500	3.0000	.3000	.0500
CALCIUM	98.0000	13.0000	83.0000	83.0000	14.0000	49.0000	28.0000	0.0000
LEAD	.0400	.0200	.0550	.1400	< .0100	.0100	.0620	0.0000
MAGNESIUM	5.1000	.5000	23.0000	13.0000	.2000	3.5000	.9000	0.0000
MERCURY	.0005	.0013	.0033	.0012	.0008	.0047	.0014	.0028
SELENIUM	< .0020	.0460	< .0020	.0170	.0060	.0080	.0100	< .0040
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	750.0000	610.0000	630.0000	0.0000	0.0000	0.0000
TOTAL ELEM	1403.8575	683.8473	1876.2703	1832.0132	1814.6628	1725.5777	1619.3384	1420.0568

POND E LEACHATE

WELL DESIG	LWE	LWE	LWE	LWE	LWE	LWE	LWE	LWE
DATE	760706.0000	761109.0000	770215.0000	770505.0000	770707.0000	770926.0000	771108.0000	780316.0000
REC NO.	10260.0000	10280.0000	10300.0000	10320.0000	10340.0000	10360.0000	10380.0000	10400.0000
PH	7.6000	7.3000	7.9000	6.4000	7.2000	7.2000	7.8000	7.2000
ALKALINITY	60.0000	64.0000	53.0000	33.0000	44.0000	36.0000	54.0000	74.0000
CHLORIDE	350.0000	260.0000	190.0000	220.0000	180.0000	120.0000	180.0000	280.0000
COD	55.0000	25.0000	6.0000	17.0000	27.0000	26.0000	0.0000	240.0000
COND	3400.0000	3300.0000	3500.0000	3200.0000	3100.0000	3600.0000	4100.0000	4400.0000
TDS	2900.0000	3000.0000	3700.0000	3230.0000	3400.0000	3100.0000	3500.0000	3700.0000
TSS	150.0000	63.0000	95.0000	14.0000	343.0000	18.0000	41.0000	160.0000
SULFATE	1000.0000	0.0000	840.0000	2500.0000	2200.0000	1900.0000	2000.0000	1200.0000
ARSENIC	.0300	.0170	.0240	.0140	.0170	.0100	< .0040	.0220
BORON	.5500	0.0000	.5000	.4900	.6500	.7000	.7000	.3000
CALCIUM	100.0000	0.0000	500.0000	340.0000	410.0000	630.0000	0.0000	400.0000
LEAD	.0130	0.0000	< .0100	< .0100	< .0100	.0120	< .0100	.0780
MAGNESIUM	11.0000	0.0000	25.0000	14.0000	19.0000	13.0000	19.0000	28.0000
MERCURY	< .0002	.0004	< .0020	.0006	.0003	< .0002	< .0002	.0004
SELENIUM	.0080	0.0000	.0030	.0020	.0050	.0030	< .0010	< .0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	610.0000	140.0000	460.0000	420.0000	320.0000	280.0000	340.0000	430.0000
TOTAL ELEM	2071.6012	400.0174	2015.5910	3494.5166	3129.6823	2943.7252	2539.7152	2338.4024

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POND E LEACHATE


WELL DESIG          LWE         LWE         LWE
DATE        780821.0000 790309.0000 800314.0000
REC NO.      10420.0000  10449.0000  17060.0000
PH               9.4100      7.2000      6.0000
ALKALINITY      79.0000     76.0000     44.0000
CHLORIDE        58.0000    220.0000    160.0000
COD              2.0000     67.0000      5.0000
COND           330.0000   4200.0000   4200.0000
TDS            210.0000   3600.0000   2200.0000
TSS              8.0000    320.0000     33.0000
SULFATE         72.0000   2100.0000   1500.0000
ARSENIC           .0300       .0120       .0070
BORON             .0600       .9000      1.1000
CALCIUM         55.0000    500.0000    550.0000
LEAD        <     .0100       .1200       .0130
MAGNESIUM        4.7000     22.0000     23.0000
MERCURY           .0004 <     .0002       .0002
SELENIUM          .0230       .0020       .0019
SULFITE          0.0000      0.0000      0.0000
SODIUM          11.0000    395.0000    330.0000
TOTAL ELEM     156.6314   3313.0342   2564.1212


POND E LEACHATE     --- AEROSPACE ---


WELL DESIG          LWE         LWE         LWE         LWE         LWE         LWE         LWE         LWE
DATE        750319.0000 750707.0000 751103.0000 760121.0000 761119.0000 770302.0000 770505.0000 780316.0000
REC NO.      10448.0000  10455.0000  10500.0000  10520.0000  10540.0000  10545.0000  10560.0000  10600.0000
PH               8.8200     10.9600      9.7400      8.1000      7.5400      7.0300      6.8100      7.5200
ALKALINITY     142.0000    548.0000    253.0000     79.0000     71.4000     20.0000     26.0000      0.0000
CHLORIDE      1050.0000    740.0000    480.0000    820.0000    373.0000    250.0000    295.0000    195.0000
COD             98.0000    245.0000    115.0000     65.0000      0.0000      0.0000      0.0000      0.0000
COND          3900.0000   4160.0000   4000.0000   3330.0000   4100.0000   3730.0000   3550.0000   3910.0000
TDS           2720.0000   3130.0000   2490.0000   2640.0000   3750.0000   3410.0000   3144.0000   3004.0000
TSS              0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE        259.0000    800.0000    903.0000   1075.0000   1950.0000   2175.0000   1875.0000   2100.0000
ARSENIC           .0100       .0000       .0140       .0760       .0520       .0310       .0090      0.0000
BORON            1.4000       .4000       .6000       .5000      1.6000       .7000       .5000 <     .5000
CALCIUM         15.0000     20.0000 <   20.0000     30.0000    340.0000    390.0000    360.0000    460.0000
LEAD              .1300       .0500 <     .0100 <     .0100       .0350       .0550       .2200      0.0000
MAGNESIUM       30.0000       .5000      0.0000       .4000     22.0000     12.0000     11.0000     34.0000
MERCURY           .0005       .0003       .0029       .0007 <     .0001 <     .0001 <     .0001      0.0000
SELENIUM          .0110       .0430       .0100       .0050       .0013 <     .0006 <     .0006      0.0000
SULFITE           .2000       .3000     38.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM         970.0000    970.0000    500.0000    540.0000    560.0000    460.0000    395.0000    445.0000
TOTAL ELEM    3116.9525   2931.5733   2018.6429   2165.9917   3243.6404   3287.7867   2936.7297   3234.5000
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POND E LEACHATE      --- AEROSPACE ---


WELL DESIG          LWE
DATE         790306.0000
REC NO.       10620.0000
PH                7.0000
ALKALINITY       78.0000
CHLORIDE        300.0000
COD               0.0000
COND           3570.0000
TDS            3552.0000
TSS               0.0000
SULFATE        1925.0000
ARSENIC     <      .0100
BORON             1.2000
CALCIUM         420.0000
LEAD        <      .0100
MAGNESIUM        26.0000
MERCURY     <      .0050
SELENIUM           .0080
SULFITE           0.0000
SODIUM          340.0000
TOTAL ELEM     3012.2330
```

POND E GROUND WELL 1

WELL DESIG	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1
DATE	750211.0000	750428.0000	750708.0000	750901.0000	751103.0000	760503.0000	760712.0000	770505.0000
REC NO.	10640.0000	10660.0000	10680.0000	10700.0000	10720.0000	10740.0000	10760.0000	10780.0000
PH	6.8000	7.0000	7.0000	7.0000	7.2000	7.3000	7.6000	6.6000
ALKALINITY	220.0000	220.0000	230.0000	200.0000	210.0000	150.0000	130.0000	86.0000
CHLORIDE	55.0000	36.0000	55.0000	40.0000	85.0000	38.0000	41.0000	49.0000
COD	25.0000	10.0000	9.0000	9.0000	47.0000	19.0000	9.0000	17.0000
COND	680.0000	630.0000	660.0000	580.0000	640.0000	640.0000	470.0000	430.0000
TDS	420.0000	390.0000	560.0000	580.0000	410.0000	420.0000	370.0000	320.0000
TSS	0.0000	90.0000	4600.0000	24000.0000	0.0000	140.0000	1600.0000	920.0000
SULFATE	36.0000	37.0000	86.0000	46.0000	67.0000	150.0000	77.0000	80.0000
ARSENIC	< .0050	< .0050	.0050	< .0050	.0050	.0150	< .0050	.0120
BORON	.2400	< .1000	.1400	.2000	.1800	.0300	0.0000	.3000
CALCIUM	32.0000	26.0000	49.0000	85.0000	16.0000	65.0000	24.0000	25.0000
LEAD	.0250	.0220	.5100	.2500	.6000	.1400	.4600	.0600
MAGNESIUM	9.4000	9.8000	19.0000	26.0000	98.0000	7.7000	9.8000	8.0000
MERCURY	< .0002	.0040	.0013	< .0002	< .0002	< .0002	< .0002	.0009
SELENIUM	< .0020	.0020	.0030	< .0020	< .0010	.0060	< .0010	.0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	0.0000	0.0000	92.0000	89.0000	120.0000	78.0000	79.0000	66.0000
TOTAL ELEM	132.6722	108.9330	301.6593	286.4572	386.7862	338.8912	231.2662	228.3749

POND E GROUND WELL 1

WELL DESIG	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1	GWE1
DATE	780105.0000	780316.0000	780511.0000	780628.0000	780821.0000	790123.0000	790312.0000	790521.0000
REC NO.	10800.0000	10820.0000	10840.0000	10860.0000	10880.0000	10900.0000	10920.0000	10940.0000
PH	6.8000	7.0000	7.4000	7.6000	7.6000	7.0000	7.0000	7.2000
ALKALINITY	110.0000	95.0000	140.0000	160.0000	190.0000	120.0000	120.0000	130.0000
CHLORIDE	42.0000	60.0000	56.0000	80.0000	25.0000	52.0000	59.0000	65.0000
COD	110.0000	120.0000	9.0000	11.0000	220.0000	8.0000	11.0000	10.0000
COND	300.0000	580.0000	700.0000	580.0000	450.0000	530.0000	510.0000	540.0000
TDS	450.0000	320.0000	550.0000	600.0000	430.0000	320.0000	320.0000	330.0000
TSS	7400.0000	1100.0000	410.0000	27000.0000	150000.0000	2100.0000	310.0000	59.0000
SULFATE	59.0000	42.0000	110.0000	33.0000	0.0000	160.0000	56.0000	47.0000
ARSENIC	.0300	< .0020	.0310	< .0040	.0020	.0020	< .0020	< .0020
BORON	.1700	.1000	.1400	.1400	.1800	.2000	.4800	3.3000
CALCIUM	28.0000	88.0000	61.0000	57.0000	100.0000	20.0000	22.0000	25.0000
LEAD	.1100	.0620	.0280	.0900	.2600	.0110	.0250	< .0100
MAGNESIUM	11.0000	18.0000	12.0000	14.0000	38.0000	7.0000	7.6000	7.8000
MERCURY	.0012	< .0002	.0003	.0017	< .0002	< .0002	< .0002	< .0002
SELENIUM	< .0020	< .0020	.0030	< .0010	.0020	.0030	.0040	.0100
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	70.0000	50.0000	73.0000	71.0000	83.0000	89.0000	81.0000	81.0000
TOTAL ELEM	210.3132	258.1662	312.2023	255.2367	246.4442	328.2162	226.1112	229.1222

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POND E GROUND WELL 1

WELL DESIG            GWE1          GWE1          GWE1          GWE1          GWE1          GWE1          GWE1
DATE           790711.0000   790912.0000   791108.0000   800115.0000   800314.0000   800518.0000   800702.0000
REC NO.         15640.0000    15660.0000    15000.0000    15020.0000    17000.0000    17500.0000    18040.0000
PH                  7.4000        7.2000        7.7000        7.2000        7.6000        7.4000        7.6000
ALKALINITY        140.0000      160.0000      150.0000      140.0000      160.0000      140.0000      160.0000
CHLORIDE           58.0000       42.0000       34.0000       41.0000       46.0000       52.0000       55.0000
COD                12.0000        4.0000        4.0000        2.0000       19.0000       11.0000        8.0000
COND              540.0000      510.0000      470.0000      780.0000      570.0000      580.0000      650.0000
TDS               330.0000      370.0000      320.0000      330.0000        0.0000      310.0000      390.0000
TSS                13.0000     8800.0000       35.0000       90.0000     2700.0000        9.0000       12.0000
SULFATE            47.0000       24.0000       62.0000       65.0000       62.0000       82.0000       62.0000
ARSENIC              .0140         .0250 <       .0020         .0050         .0020 <       .0020 <       .0020
BORON               1.5000         .0800         .1400        3.1000         .1600         .1150         .2200
CALCIUM            28.0000       36.0000       25.0000       28.0000       25.0000       23.0000       35.0000
LEAD         <       .0100 <       .0100         .0300         .0180         .0330         .0080         .0310
MAGNESIUM           8.0000       14.0000        6.7000        8.8000        9.2000        8.1000       13.0000
MERCURY      <       .0002 <       .0002 <       .0002 <       .0002         .0002 <       .0002 <       .0002
SELENIUM             .0040         .0070         .0010         .0020         .0010         .0020         .0010
SULFITE             0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM             81.0000       86.0000       46.0000       94.0000       84.0000       87.0000       85.0000
TOTAL ELEM        223.5282      202.1222      173.8732      239.9252      226.3962      252.2272      250.2542


POND E GROUND WELL 1--- AEROSPACE ---

WELL DESIG            GWE1          GWE1          GWE1          GWE1          GWE1          GWE1          GWE1          GWE1
DATE           750211.0000   750707.0000   751103.0000   760503.0000   770505.0000   780309.0000   780316.0000   790314.0000
REC NO.         10960.0000    10980.0000    11000.0000    11020.0000    11040.0000    11060.0000    11080.0000    11100.0000
PH                  7.3400        7.2500        7.3700        7.7800        7.2100        7.9900        7.9900        7.6000
ALKALINITY        223.0000      217.0000      177.0000        0.0000       87.0000       79.0000      106.0000      133.0000
CHLORIDE          115.0000       71.0000       72.0000       62.0000       88.0000       67.0000       54.0000       90.0000
COD                50.0000        0.0000       10.0000        0.0000        0.0000        0.0000        0.0000        0.0000
COND              640.0000      550.0000     2440.0000      560.0000      420.0000      413.0000      617.0000      454.0000
TDS               416.0000      440.0000      380.0000      384.0000      270.0000      316.0000      462.0000      304.0000
TSS                 0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SULFATE            28.0000       70.0000       55.0000       80.0000       69.0000       60.0000      125.0000       48.0000
ARSENIC              .0050         .0040         .0100        0.0000         .0080         .0700        0.0000         .0100
BORON                .1000         .2000         .7000        1.0000         .6000 <       .5000        4.2000         .3000
CALCIUM            32.0000       13.0000        8.0000       42.0000       23.0000       13.0000       45.0000       21.0000
LEAD                 .0400         .0500 <       .0200 <       .0100         .0500         .2400        0.0000 <       .0900
MAGNESIUM          15.0000       11.7000       12.0000       10.0000        5.6000       12.0000       17.0000       10.0000
MERCURY              .0003         .0004         .0003        0.0000         .0001         .0007        0.0000         .0020
SELENIUM             .0050         .0005         .0020        0.0000         .0027         .0010        0.0000         .0440
SULFITE              .3000         .6400         .3000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM              0.0000        0.0000       99.0000       83.0000       65.0000       65.0000       60.0000       65.0000
TOTAL ELEM        190.4503      166.5949      247.0323      278.0100      251.2608      217.8117      305.2000      234.4460
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POND E GROUND WELL 2

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WELL DESIG             GWE2           GWE2           GWE2           GWE2           GWE2           GWE2           GWE2           GWE2
DATE            740805.0000    740903.0000    741007.0000    741028.0000    741104.0000    750211.0000    750428.0000    750708.0000
REC NO.          11120.0000     11140.0000     11160.0000     11180.0000     11200.0000     11220.0000     11240.0000     11260.0000
PH                   7.0000         7.2000         7.2000         0.0000         7.0000         6.9000         6.8000         6.8000
ALKALINITY         110.0000        94.0000       170.0000         0.0000       100.0000       230.0000       160.0000       150.0000
CHLORIDE            50.0000        28.0000        66.0000         0.0000        29.0000        63.0000        46.0000        52.0000
COD                  0.0000         0.0000         0.0000         0.0000         0.0000       860.0000        31.0000       120.0000
COND                 0.0000         0.0000         0.0000         0.0000       490.0000      1000.0000       590.0000       600.0000
TDS                400.0000       220.0000       370.0000         0.0000       320.0000       460.0000       350.0000       480.0000
TSS               5400.0000         0.0000       180.0000         0.0000       190.0000         0.0000        25.0000      7500.0000
SULFATE             48.0000        26.0000        40.0000         0.0000        69.0000        52.0000        50.0000        89.0000
ARSENIC               .0230 <        .0050 <        .0050 <        .0050 <        .0050 <        .0050 <        .0050 <        .0050
BORON        <        .1000 <        .1000 <        .1000 <        .1000 <        .1000          .5000          .1500          .1800
CALCIUM             31.0000        22.0000        23.0000         0.0000        35.0000        72.0000        34.0000        62.0000
LEAD                  .0950          .0160          .0100         0.0000          .0100          .8900 <        .0100          .2500
MAGNESIUM           24.0000         5.6000         8.3000         0.0000         8.8000        12.0000         8.5000        16.0000
MERCURY      <        .0002 <        .0002 <        .0002         0.0000          .0002          .0005          .0002 <        .0002
SELENIUM     <        .0020 <        .0020 <        .0020 <        .0020 <        .0020 <        .0020 <        .0020 <        .0020
SULFITE              0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
SODIUM               0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
TOTAL ELEM         153.2202        81.7232       137.4172          .1070       141.9172       200.3975       138.6672       219.4372
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POND E GROUND WELL 2

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WELL DESIG             GWE2           GWE2           GWE2           GWE2           GWE2           GWE2           GWE2           GWE2
DATE            750901.0000    760503.0000    760712.0000    780323.0000    780511.0000    780628.0000    790123.0000    790312.0000
REC NO.          11280.0000     11300.0000     11320.0000     11340.0000     11360.0000     11380.0000     11400.0000     11420.0000
PH                   7.0000         7.3000         7.8000         7.1000         7.2000         7.6000         7.7000         7.4000
ALKALINITY         120.0000       200.0000       250.0000       180.0000       170.0000       170.0000       230.0000       130.0000
CHLORIDE            32.0000        28.0000        38.0000        21.0000        20.0000        30.0000        36.0000        21.0000
COD                 37.0000         0.0000        37.0000       190.0000        40.0000        19.0000         9.0000        19.0000
COND               480.0000       640.0000       570.0000       500.0000       500.0000       540.0000       970.0000       700.0000
TDS                340.0000       430.0000       390.0000       350.0000       370.0000       400.0000       610.0000       490.0000
TSS              29000.0000       550.0000       150.0000      3400.0000      1500.0000       180.0000       480.0000       760.0000
SULFATE            150.0000       100.0000        15.0000        43.0000        60.0000        58.0000       220.0000       230.0000
ARSENIC               .0150 <        .0050 <        .0050          .0060          .0220          .0220          .0110          .0020
BORON                 .8000          .1000          .3800          .1500          .1500          .2800          .3800         1.0000
CALCIUM             71.0000        55.0000        46.0000        71.0000        69.0000        79.0000       150.0000       100.0000
LEAD                  .0850          .0210          .1700          .2800          .0920          .2000          .1300          .0250
MAGNESIUM           11.0000         8.8000         8.4000         7.1000         8.8000         8.1000        12.0000         7.8000
MERCURY      <        .0002 <        .0002 <        .0002 <        .0002          .0010          .0050 <        .0002 <        .0002
SELENIUM     <        .0020 <        .0040          .0010 <        .0020          .0020 <        .0010          .0030          .0010
SULFITE              0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000         0.0000
SODIUM               0.0000         0.0000         0.0000        41.0000        29.0000        37.0000        79.0000        29.0000
TOTAL ELEM         264.9022       191.9302       107.9562       183.5382       187.0670       212.6080       497.5242       383.8282
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POND E GROUND WELL 2

WELL DESIG         GWE2        GWE2        GWE2        GWE2        GWE2        GWE2        GWE2        GWE2
DATE        790524.0000 790711.0000 790912.0000 791108.0000 800115.0000 800314.0000 800518.0000 800702.0000
REC NO.      11440.0000  15600.0000  15620.0000  15040.0000  15060.0000  16980.0000  17520.0000  18060.0000
PH               7.3000      7.4000      7.5000      7.3000      7.0000      7.4000      7.4000      7.4000
ALKALINITY     220.0000    180.0000    190.0000    210.0000    160.0000    180.0000    150.0000    160.0000
CHLORIDE        20.0000     38.0000     44.0000     50.0000     33.0000     44.0000     42.0000     36.0000
COD             17.0000     13.0000     12.0000      8.0000      6.0000      8.0000     12.0000     12.0000
COND           740.0000    720.0000    690.0000    680.0000    730.0000    740.0000    720.0000    740.0000
TDS            510.0000    480.0000    500.0000    450.0000    460.0000    460.0000    360.0000    480.0000
TSS             23.0000     39.0000    230.0000    110.0000     13.0000      6.0000      6.0000     50.0000
SULFATE        200.0000    160.0000    140.0000    110.0000    150.0000      0.0000    160.0000    160.0000
ARSENIC           .0020       .0050       .0030       .0030 <     .0020 <     .0020       .0030 <     .0020
BORON             .3800      3.2000       .4000 <     .5000      3.6000       .1900       .1000       .2000
CALCIUM        150.0000    120.0000     92.0000    150.0000     92.0000     67.0000    110.0000     93.0000
LEAD              .0310 <     .0100       .0100       .0460       .0140 <     .0100       .0210       .0120
MAGNESIUM        7.6000      7.0000      8.5000      6.7000      6.7000      7.5000      8.5000      8.2000
MERCURY     <     .0020 <     .0002 <     .0002 <     .0002 <     .0002       .0002 <     .0002       .0003
SELENIUM          .0010 <     .0010 <     .0010       .0010 <     .0010 <     .0010 <     .0010 <     .0010
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           6.3000     45.0000     65.0000     78.0000     91.0000     73.0000     49.0000     49.0000
TOTAL ELEM     384.3160    373.2162    347.9142    395.2502    376.3172    191.7032    369.6252    346.4153


POND E GROUND WELL 2--- AEROSPACE ---

WELL DESIG         GWE2        GWE2        GWE2        GWE2        GWE2        GWE2
DATE        741028.0000 750428.0000 750708.0000 760503.0000 790314.0000 791108.0000
REC NO.      11460.0000  11480.0000  11500.0000  11520.0000  11540.0000  16420.0000
PH               8.3600      7.6300      6.8900      7.5100      7.2000      7.0000
ALKALINITY     181.0000      0.0000    176.0000      0.0000    141.0000    206.4000
CHLORIDE        84.0000    125.0000     64.0000     62.0000     23.0000     56.0000
COD             50.0000      0.0000     15.0000      0.0000      0.0000      0.0000
COND           610.0000    640.0000    500.0000    620.0000    625.0000    613.0000
TDS            384.0000    544.0000    400.0000    522.0000    482.0000    368.0000
TSS              0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE         37.0000     56.0000    110.0000    110.0000    197.0000     80.0000
ARSENIC           .0050       .0050       .0040      0.0000       .0300       .0100
BORON             .3000       .6000       .2000      1.0000       .6000 <     .5000
CALCIUM         20.0000     20.0000     37.0000     63.0000    120.0000     53.0000
LEAD              .0300       .0900       .0500 <     .0100 <     .0900       .0800
MAGNESIUM       15.0000     12.0000      7.5000     11.0000     13.0000     15.4000
MERCURY          0.0000      0.0000      0.0000      0.0000       .0015       .0001
SELENIUM          .0040       .0030       .0010      0.0000       .0050       .0060
SULFITE           .3000       .7000       .4400      0.0000      0.0000      0.0000
SODIUM          79.0000      0.0000      0.0000     62.0000     25.0000     85.0000
TOTAL ELEM     235.6390    214.3980    219.1950    309.0100    378.7265    289.9961
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POND F UNDERDRAIN

WELL DESIG	UDF	UDF	UDF	UDF	UDF	UDF	UDF	UDF
DATE	770505.0000	770713.0000	770926.0000	771104.0000	780316.0000	780511.0000	790319.0000	790713.0000
REC NO.	11560.0000	11580.0000	11600.0000	11620.0000	11640.0000	11660.0000	11680.0000	16120.0000
PH	10.5000	8.5000	9.0000	7.9000	0.0000	7.7000	8.6000	7.4000
ALKALINITY	82.0000	40.0000	43.0000	44.0000	0.0000	280.0000	58.0000	56.0000
CHLORIDE	890.0000	910.0000	720.0000	1700.0000	0.0000	50.0000	1000.0000	370.0000
COD	33.0000	27.0000	17.0000	15.0000	25.0000	15.0000	23.0000	12.0000
COND	3400.0000	4800.0000	4200.0000	5300.0000	0.0000	1500.0000	5200.0000	3000.0000
TDS	4100.0000	4000.0000	3700.0000	4100.0000	0.0000	980.0000	4900.0000	2800.0000
TSS	12.0000	17.0000	31.0000	37.0000	0.0000	25.0000	89.0000	5.0000
SULFATE	1400.0000	1200.0000	1400.0000	1500.0000	0.0000	380.0000	1400.0000	1200.0000
ARSENIC	.0070	< .0040	.0030	.0040	.0040	.0060	.0130	.0100
BORON	9.9000	7.0000	16.0000	12.0000	0.0000	1.2000	9.8000	7.8000
CALCIUM	750.0000	1100.0000	1200.0000	1600.0000	290.0000	200.0000	1000.0000	570.0000
LEAD	< .0100	< .0100	< .0100	< .0100	< .0100	< .0100	.0100	< .0100
MAGNESIUM	2.0000	1.4000	19.0000	6.7000	30.0000	33.0000	58.0000	47.0000
MERCURY	< .0002	.0010	< .0002	< .0002	< .0002	.0006	< .0002	< .0002
SELENIUM	.0270	.0340	.0240	.0240	< .0020	< .0010	.0020	.0020
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	50.0000	64.0000	41.0000	50.0000	97.0000	92.0000	96.0000	34.0000
TOTAL ELEM	3101.9442	3282.4490	3396.0372	4868.7382	417.0162	756.2176	3563.8252	2228.8222

POND F UNDERDRAIN

WELL DESIG	UDF	UDF
DATE	790926.0000	800401.0000
REC NO.	16140.0000	17880.0000
PH	7.9000	6.4000
ALKALINITY	68.0000	21.0000
CHLORIDE	550.0000	24.0000
COD	34.0000	15.0000
COND	4000.0000	2600.0000
TDS	3800.0000	2100.0000
TSS	190.0000	22.0000
SULFATE	1600.0000	1600.0000
ARSENIC	.0020	.0190
BORON	16.0000	2.3000
CALCIUM	68.0000	680.0000
LEAD	< .0100	.0020
MAGNESIUM	64.0000	8.3000
MERCURY	< .0002	.0002
SELENIUM	.0310	.0020
SULFITE	0.0000	0.0000
SODIUM	43.0000	9.9000
TOTAL ELEM	2341.0432	2324.5232

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POND F UNDERDRAIN   --- AEROSPACE ---


WELL DESIG          UDF         UDF         UDF         UDF
DATE        770505.0000 780309.0000 780316.0000 790314.0000
REC NO.      11700.0000  11720.0000  11740.0000  11760.0000
PH               9.9200      7.7100      7.8100      7.1000
ALKALINITY      44.0000    200.0000     60.0000     48.0000
CHLORIDE       980.0000    250.0000    140.0000   1150.0000
COD              0.0000      0.0000      0.0000      0.0000
COND          4130.0000   1480.0000   1820.0000   4030.0000
TDS           3342.0000   1182.0000   1848.0000   3582.0000
TSS              0.0000      0.0000      0.0000      0.0000
SULFATE       1225.0000    430.0000   1000.0000   1425.0000
ARSENIC     <     .0010       .0030      0.0000 <     .0100
BORON            9.0000      1.3000      4.2000     12.0000
CALCIUM        940.0000    200.0000    360.0000    660.0000
LEAD              .3200       .2400      0.0000       .1500
MAGNESIUM        1.8000     52.0000     50.0000     62.0000
MERCURY     <     .0001 <     .0001      0.0000       .0070
SELENIUM    <     .0006       .0001      0.0000       .0110
SULFITE          0.0000      0.0000      0.0000      0.0000
SODIUM          51.0000     90.0000      8.9000     62.0000
TOTAL ELEM    3207.1217   1023.5482   1563.1000   3371.1780
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POND F GROUND WELL 1

WELL DESIG         GWF1        GWF1        GWF1        GWF1        GWF1        GWF1        GWF1        GWF1
DATE        770505.0000 770707.0000 771216.0000 780316.0000 780511.0000 780628.0000 780821.0000 781211.0000
REC NO.      11780.0000  11800.0000  11820.0000  11840.0000  11860.0000  11880.0000  11900.0000  11920.0000
PH               6.6000      7.8000      7.1000      6.7000      6.7000      7.5000      6.7000      7.0000
ALKALINITY     160.0000    140.0000    130.0000    130.0000    120.0000    110.0000     99.0000     94.0000
CHLORIDE        46.0000     54.0000     42.0000     64.0000    110.0000    120.0000    120.0000     84.0000
COD             14.0000     16.0000     18.0000      5.0000      5.0000      7.0000     13.0000     38.0000
COND           450.0000    430.0000    440.0000    490.0000    700.0000    690.0000    520.0000    500.0000
TDS            290.0000    250.0000    240.0000    280.0000    440.0000    390.0000    370.0000    330.0000
TSS             81.0000     13.0000    870.0000    420.0000   1200.0000   1600.0000   1300.0000   3000.0000
SULFATE         15.0000     32.0000<     2.0000      8.0000     18.0000     12.0000     12.0000     15.0000
ARSENIC           .0030<      .0020       .0170<      .0040       .0190<      .0040       .0050<      .0020
BORON             .1300       .0400       .0700       .0400       .0600       .1600       .0600       .1100
CALCIUM         43.0000     42.0000     33.0000     38.0000     57.0000     48.0000     43.0000     50.0000
LEAD              .0250<      .0100       .3800       .0110       .0350       .0700       .0590       .2100
MAGNESIUM       14.0000      9.5000     14.0000     12.0000     22.0000     19.0000     17.0000     15.0000
MERCURY    <      .0002<      .0002       .0025<      .0002       .0006       .0006<      .0002<      .0002
SELENIUM          .0090<      .0020<      .0020       .0020       .0020       .0020       .0020<      .0010
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          43.0000     35.0000     33.0000     33.0000     60.0000     43.0000     46.0000     42.0000
TOTAL ELEM     161.1672    172.5542    124.4715    155.0572    267.1166    242.2366    238.1262    206.3232


POND F GROUND WELL 1

WELL DESIG         GWF1        GWF1        GWF1        GWF1        GWF1        GWF1        GWF1        GWF1
DATE        790312.0000 790521.0000 790711.0000 790912.0000 791113.0000 800115.0000 800314.0000 800518.0000
REC NO.      11940.0000  11960.0000  15680.0000  15700.0000  15080.0000  15100.0000  17020.0000  17540.0000
PH               6.7000      6.9000      7.0000      7.0000      7.1000      7.0000      7.1000      7.0000
ALKALINITY     150.0000    250.0000    110.0000     97.0000     83.0000     44.0000    100.0000    110.0000
CHLORIDE       140.0000    230.0000    150.0000    130.0000    100.0000     74.0000     78.0000    120.0000
COD              8.0000     15.0000     13.0000      4.0000      3.0000      2.0000     11.0000     11.0000
COND           810.0000   1200.0000    720.0000    610.0000    490.0000    530.0000    520.0000    680.0000
TDS            500.0000    700.0000    470.0000    400.0000    320.0000    270.0000    490.0000    370.0000
TSS            910.0000    210.0000    100.0000   2300.0000    220.0000    210.0000    310.0000    140.0000
SULFATE         36.0000     21.0000     15.0000     15.0000     14.0000     10.0000     11.0000     12.0000
ARSENIC    <      .0020       .0040       .0020       .0150<      .0020<      .0020<      .0020<      .0020
BORON             .4200       .0060       .1600       .1000      3.1000       .1000      1.3000       .0920
CALCIUM         46.0000    100.0000     41.0000     50.0000     65.0000     36.0000     33.0000     34.0000
LEAD              .0260<      .0100       .0190       .0180       .0300<      .0100<      .0100       .0090
MAGNESIUM       22.0000     24.0000     20.0000     16.0000     17.0000     14.0000     13.0000     16.0000
MERCURY    <      .0002<      .0002<      .0002<      .0002<      .0002<      .0002<      .0002<      .0002
SELENIUM          .0030       .0030       .0020       .0040       .0030       .0030       .0030       .0030
SULFITE          0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM          92.0000    150.0000     93.0000     59.0000     43.0000     39.0000     42.0000     56.0000
TOTAL ELEM     336.4512    525.0232    319.1632    270.1372    242.1352    173.1152    178.3152    238.1062
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POND F GROUND WELL 1

WELL DESIG         GWF1
DATE        800702.0000
REC NO.      18080.0000
PH               7.3000
ALKALINITY      48.0000
CHLORIDE       120.0000
COD              9.0000
COND           620.0000
TDS            390.0000
TSS             66.0000
SULFATE          9.0000
ARSENIC     <     .0020
BORON             .0700
CALCIUM         37.0000
LEAD              .0160
MAGNESIUM       15.0000
MERCURY           .0002
SELENIUM          .0020
SULFITE          0.0000
SODIUM          54.0000
TOTAL ELEM     235.0902
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POND F GROUND WELL 1--- AEROSPACE ---

WELL DESIG         GWF1          GWF1          GWF1          GWF1
DATE        770505.0000   780309.0000   780316.0000   790314.0000
REC NO.      11980.0000    12000.0000    12020.0000    12040.0000
PH               7.1800        8.0000        8.1900        7.5000
ALKALINITY     158.0000      120.0000      116.0000      108.8000
CHLORIDE        70.0000      105.0000      100.0000      200.0000
COD              0.0000        0.0000        0.0000        0.0000
COND           440.0000      405.0000      413.0000      617.0000
TDS            250.0000      258.0000      256.0000      374.0000
TSS              0.0000        0.0000        0.0000        0.0000
SULFATE         14.0000       10.0000       10.0000       38.0000
ARSENIC           .0140         .0080        0.0000         .0600
BORON            1.5000  <      .5000        2.8000        1.2000
CALCIUM         40.0000       31.0000       27.0000       70.0000
LEAD              .0450         .1600        0.0000  <      .0900
MAGNESIUM       10.9000       13.0000       13.0000       20.0000
MERCURY     <     .0001  <      .0001        0.0000         .0016
SELENIUM    <     .0006         .0001        0.0000         .0240
SULFITE          0.0000        0.0000        0.0000        0.0000
SODIUM          41.0000       40.0000       35.0000       50.0000
TOTAL ELEM     177.4597      199.6682      187.8000      379.3756
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POND F GROUND WELL 2

WELL DESIG            GWF2          GWF2          GWF2          GWF2          GWF2          GWF2          GWF2          GWF2
DATE           770505.0000   770707.0000   770926.0000   771104.0000   771216.0000   780316.0000   780511.0000   780628.0000
REC NO.         12060.0000    12080.0000    12100.0000    12120.0000    12140.0000    12160.0000    12180.0000    12200.0000
PH                  7.1000        7.5000        7.6000        7.5000        7.4000        7.1000        7.2000        7.8000
ALKALINITY        160.0000      280.0000      280.0000      290.0000      280.0000      240.0000      270.0000      270.0000
CHLORIDE           22.0000       17.0000       30.0000       15.0000       15.0000       12.0000       14.0000       15.0000
COD                34.0000       11.0000       21.0000       13.0000       50.0000        9.0000        7.0000        9.0000
COND              600.0000      630.0000      700.0000      700.0000      710.0000      610.0000      680.0000      690.0000
TDS               410.0000      470.0000      450.0000      460.0000      500.0000      390.0000      450.0000      430.0000
TSS                33.0000        2.0000       26.0000       19.0000     1900.0000       26.0000       25.0000      500.0000
SULFATE            58.0000       83.0000       62.0000       68.0000       72.0000       48.0000       68.0000       76.0000
ARSENIC              .0030         .0030         .0040 <       .0040         .0040 <       .0020 <       .0040 <       .0040
BORON                .3600         .0400         .1400         .1200         .0800         .0200         .2800         .1800
CALCIUM            46.0000       29.0000       36.0000       28.0000       28.0000       20.0000       28.0000       28.0000
LEAD                 .0120 <       .0100         .0260         .0440         .3800         .0160 <       .0100         .0760
MAGNESIUM          13.0000       14.0000        9.8000       12.0000       15.0000        9.1000       11.0000       13.0000
MERCURY      <       .0002 <       .0002         .0021         .0009         .0009 <       .0002         .0005         .0007
SELENIUM     <       .0020 <       .0010 <       .0010 <       .0010 <       .0020 <       .0020 <       .0010 <       .0010
SULFITE             0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            110.0000      120.0000       13.0000      130.0000      140.0000      110.0000      110.0000      130.0000
TOTAL ELEM        249.3772      263.0542      150.9731      253.1699      270.4669      199.1402      231.2955      262.2617
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POND F GROUND WELL 2

WELL DESIG            GWF2          GWF2          GWF2          GWF2          GWF2          GWF2          GWF2          GWF2
DATE           780821.0000   781211.0000   790522.0000   790711.0000   790912.0000   791113.0000   800115.0000   800314.0000
REC NO.         12220.0000    12240.0000    12260.0000    15720.0000    15740.0000    15120.0000    15140.0000    17040.0000
PH                  7.8000        6.9000        7.0000        7.4000        7.1000        7.6000        6.8000        7.6000
ALKALINITY        270.0000      230.0000      280.0000      240.0000      240.0000      220.0000       68.0000      200.0000
CHLORIDE           16.0000       13.0000       11.0000       22.0000       23.0000       16.0000       14.0000       17.0000
COD                 7.0000        5.0000       10.0000        8.0000        8.0000        5.0000        4.0000       12.0000
COND              640.0000      600.0000      560.0000      610.0000      590.0000      540.0000      430.0000      560.0000
TDS               430.0000      300.0000      370.0000      430.0000      410.0000      390.0000      310.0000      360.0000
TSS                67.0000       92.0000        9.0000       13.0000       44.0000        5.0000        6.0000         .8000
SULFATE            68.0000       62.0000       77.0000       70.0000       70.0000        7.0000       59.0000       72.0000
ARSENIC              .0020 <       .0020 <       .0020 <       .0020         .0020 <       .0020 <       .0020 <       .0020
BORON                .0800         .1300         .1500         .1800         .1300         .0100         .0600         .1700
CALCIUM            20.0000       22.0000       23.0000       21.0000       22.0000       11.0000       18.0000       18.0000
LEAD         <       .0100 <       .0100 <       .0100 <       .0100         .0350         .0220 <       .0100 <       .0100
MAGNESIUM          11.0000        8.5000        9.1000        9.2000       11.0000        8.9000        6.8000        8.4000
MERCURY      <       .0002 <       .0002 <       .0002 <       .0002 <       .0002 <       .0002 <       .0002 <       .0002
SELENIUM     <       .0010 <       .0010 <       .0010 <       .0010 <       .0010 <       .0010 <       .0010 <       .0010
SULFITE             0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            120.0000      110.0000       89.0000      130.0000      100.0000       93.0000      110.0000       93.0000
TOTAL ELEM        235.0932      215.6432      209.2632      252.3932      226.1682      135.9352      207.8732      208.5832
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POND F GROUND WELL 2

WELL DESIG          GWF2        GWF2
DATE         800518.0000 800702.0000
REC NO.       17560.0000  18100.0000
PH                7.0000      7.6000
ALKALINITY      230.0000    240.0000
CHLORIDE         19.0000     16.0000
COD              15.0000      6.0000
COND            610.0000    700.0000
TDS             370.0000    470.0000
TSS              13.0000     26.0000
SULFATE          70.0000     80.0000
ARSENIC            .0020       .0020
BORON              .0500       .1100
CALCIUM          23.0000     20.0000
LEAD               .0060       .0120
MAGNESIUM        10.0000      9.6000
MERCURY     <      .0002 <     .0002
SELENIUM    <      .0010 <     .0010
SULFITE           0.0000      0.0000
SODIUM          100.0000    100.0000
TOTAL ELEM      222.0592    225.7252
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POND F GROUND WELL 2--- AEROSPACE ---

WELL DESIG          GWF2        GWF2        GWF2        GWF2
DATE         770505.0000 780309.0000 780316.0000 791113.0000
REC NO.       12280.0000  12300.0000  12320.0000  16440.0000
PH                7.5700      8.0200      8.4000      7.0900
ALKALINITY      283.0000    245.0000    127.0000    222.8000
CHLORIDE         75.0000     15.0000     20.0000     18.0000
COD               0.0000      0.0000      0.0000      0.0000
COND            510.0000    556.0000    543.0000    500.0000
TDS             380.0000    422.0000    360.0000    304.0000
TSS               0.0000      0.0000      0.0000      0.0000
SULFATE          64.0000     60.0000     54.0000     65.0000
ARSENIC            .0310 <     .0040      0.0000       .0100
BORON              .3000 <     .5000      1.7000 <     .5000
CALCIUM          27.0000     19.0000     15.0000     20.0000
LEAD               .0500       .2000      0.0000       .0100
MAGNESIUM        10.7000     11.0000     11.0000     15.4000
MERCURY     <      .0001       .0009      0.0000       .0001
SELENIUM           .0033       .0001      0.0000       .0080
SULFITE           0.0000      0.0000      0.0000      0.0000
SODIUM           96.0000    110.0000    107.0000     11.0000
TOTAL ELEM      273.0844    215.7050    208.7000    129.9281
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POND G UNDERDRAIN

WELL DESIG          UDG          UDG          UDG          UDG          UDG          UDG          UDG          UDG
DATE        770505.0000  770707.0000  770926.0000  780316.0000  780511.0000  780628.0000  780821.0000  781211.0000
REC NO.      12340.0000   12360.0000   12380.0000   12400.0000   12420.0000   12440.0000   12460.0000   12480.0000
PH               6.8000       7.3000       7.3000       0.0000       6.9000       7.4000       7.6000       7.1000
ALKALINITY     170.0000      99.0000      66.0000       0.0000     120.0000     270.0000     160.0000      46.0000
CHLORIDE       280.0000     700.0000     290.0000       0.0000     300.0000     300.0000     340.0000      94.0000
COD             15.0000      14.0000      24.0000      10.0000       5.0000      18.0000      22.0000       2.0000
COND          2000.0000    3700.0000    3200.0000       0.0000    3200.0000    3000.0000    3200.0000    2500.0000
TDS           2100.0000    4300.0000    2900.0000       0.0000    2600.0000    2300.0000    2700.0000    2300.0000
TSS              4.0000       9.0000       5.0000       0.0000     220.0000     390.0000       6.0000       4.0000
SULFATE        890.0000    1900.0000    1400.0000       0.0000    1300.0000    1000.0000       0.0000    1400.0000
ARSENIC     <     .0020  <     .0040  <     .0020  <     .0040        .0040        .0100  <     .0020        .0020
BORON            6.8000      23.0000      18.0000       0.0000       7.0000       0.0000      18.0000       5.2000
CALCIUM        260.0000     660.0000     880.0000     470.0000     590.0000     640.0000     590.0000     580.0000
LEAD              .0100  <     .0100  <     .0100  <     .0100        .0450        .1000  <     .0100  <     .0100
MAGNESIUM      120.0000     250.0000     130.0000      30.0000     120.0000     120.0000      83.0000      30.0000
MERCURY           .0006  <     .0002  <     .0004  <     .0002        .0003        .0005  <     .0002  <     .0002
SELENIUM    <     .0100        .0420        .0190        .0070        .0050        .0140        .0240        .0210
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM          30.0000      31.0000      18.0000       6.5000      20.0000      23.0000      25.0000       5.9000
TOTAL ELEM    1586.8226    3564.0562    2736.0314     506.5212    2337.0543    2083.1245    1056.0362    2115.1332
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POND G UNDERDRAIN

WELL DESIG          UDG          UDG          UDG          UDG          UDG          UDG
DATE        790713.0000  790926.0000  791113.0000  800111.0000  800311.0000  800515.0000
REC NO.      16160.0000   16180.0000   15160.0000   15180.0000   17340.0000   17840.0000
PH               7.4000       6.9000       7.6000       7.2000       7.3000       7.5000
ALKALINITY     190.0000     170.0000      71.0000      52.0000     210.0000     200.0000
CHLORIDE        89.0000      76.0000     110.0000      32.0000      83.0000      70.0000
COD              7.0000      32.0000       2.0000       2.0000      10.0000      12.0000
COND          2000.0000    2000.0000    2400.0000    1900.0000    1800.0000    1700.0000
TDS           1800.0000    1800.0000    2300.0000    1900.0000    1800.0000    1200.0000
TSS             12.0000       5.0000       5.0000       5.0000       3.0000       4.0000
SULFATE        800.0000     920.0000    1400.0000    1100.0000     730.0000     850.0000
ARSENIC           .0050        .0280  <     .0020  <     .0020  <     .0020        .0020
BORON            6.6000       8.0000      60.0000      32.0000       6.0000       2.3000
CALCIUM        390.0000     690.0000     950.0000     540.0000     290.0000     330.0000
LEAD        <     .0100  <     .0100  <     .0100  <     .0100  <     .0100        .0010
MAGNESIUM       64.0000      66.0000      84.0000      36.0000      63.0000      54.0000
MERCURY     <     .0002  <     .0002  <     .0002        .0004        .0009  <     .0002
SELENIUM          .0030        .0110        .0450        .0030        .0100        .0020
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM          19.0000      16.0000      14.0000       9.6000      24.0000      24.0000
TOTAL ELEM    1368.6182    1776.0492    2618.0572    1749.6154    1196.0229    1330.3052
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POND G UNDERDRAIN   --- AEROSPACE ---


WELL DESIG          UDG         UDG         UDG         UDG         UDG
DATE        770505.0000 780309.0000 780316.0000 790327.0000 791113.0000
REC NO.      12500.0000  12520.0000  12540.0000  12560.0000  16460.0000
PH              7.3000      7.4600      7.6400      6.9000      7.2500
ALKALINITY    175.0000     49.6000    280.0000     46.0000     67.0000
CHLORIDE      385.0000    930.0000    900.0000    125.0000    130.0000
COD             0.0000      0.0000      0.0000      0.0000      0.0000
COND         2250.0000   3450.0000   3360.0000   2080.0000   2190.0000
TDS          1720.0000   3116.0000   2664.0000   2266.0000   2316.0000
TSS             0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE       900.0000   1475.0000    876.0000   1137.0000   1200.0000
ARSENIC          .0140       .0080      0.0000       .0500       .0200
BORON           6.7000     23.0000     32.0000     11.0000       .1000
CALCIUM       390.0000    600.0000    410.0000    420.0000    380.0000
LEAD             .1900       .6000      0.0000       .2200       .0300
MAGNESIUM     103.0000    217.0000    249.0000     48.0000     64.5000
MERCURY     <    .0001       .0010      0.0000       .0013 <     .0002
SELENIUM         .0017       .0004      0.0000       .0000       .0070
SULFITE         0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM         29.0000     25.0000     52.0000      8.1000     15.0000
TOTAL ELEM   1813.9055   3270.6094   2519.0000   1749.3793   1789.7372
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POND G GROUND WELL 1

WELL DESIG            GWS1          GWS1          GWS1          GWS1          GWS1          GWS1          GWS1          GWS1
DATE           770505.0000   770707.0000   771104.0000   771216.0000   780316.0000   780511.0000   780628.0000   780821.0000
REC NO.         12500.0000    12600.0000    12620.0000    12640.0000    12660.0000    12680.0000    12700.0000    12720.0000
PH                  6.0000        6.0000        6.6000        6.2000        6.1000        6.1000        6.7000        6.8000
ALKALINITY         22.0000       23.0000       22.0000       26.0000       20.0000       18.0000       24.0000       26.0000
CHLORIDE           12.0000       16.0000       12.0000       15.0000       12.0000       13.0000       16.0000       28.0000
COD                 4.0000        4.0000        4.0000       45.0000        3.0000        1.0000        3.0000       13.0000
COND              170.0000      140.0000      170.0000      200.0000      180.0000      180.0000     1600.0000      190.0000
TDS               130.0000      150.0000      190.0000      340.0000      180.0000      210.0000      280.0000      150.0000
TSS               160.0000       70.0000      300.0000     2700.0000     1400.0000     1400.0000     1900.0000      980.0000
SULFATE            41.0000       28.0000       28.0000        7.0000       52.0000       40.0000       20.0000       57.0000
ARSENIC              .0040         .0020  <      .0040  <      .0020  <      .0020         .0160  <      .0040  <      .0020
BORON                .1500         .0400         .0400         .0500         .1300         .1200         .1100         .2500
CALCIUM            14.0000       10.0000       14.0000       11.0000       12.0000       13.0000       14.0000       12.0000
LEAD                 .0110         .0100         .0270         .0720         .0110         .0150         .0490         .0250
MAGNESIUM           5.2000        4.2000        4.3000        4.6000        4.5000        5.6000        5.6000        4.7000
MERCURY       <      .0002         .0002  <      .0002         .0004  <      .0002  <      .0002         .0011  <      .0002
SELENIUM             .0080  <      .0010         .0010  <      .0020  <      .0020  <      .0010  <      .0010         .0010
SULFITE             0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM             14.0000       12.0000       13.0000       14.0000       11.0000       11.0000       12.0000       14.0000
TOTAL ELEM         86.3732       70.2532       71.3722       51.7264       91.6452       82.7522       67.7651      115.9782


POND G GROUND WELL 1

WELL DESIG            GWS1          GWS1          GWS1          GWS1          GWS1          GWS1          GWS1          GWS1
DATE           790309.0000   790312.0000   790524.0000   790713.0000   790912.0000   791108.0000   800114.0000   800314.0000
REC NO.         12740.0000    12760.0000    12780.0000    15760.0000    15780.0000    15200.0000    15220.0000    17060.0000
PH                  6.2000        6.1000        6.1000        5.6000        6.2000        6.4000        6.0000        6.5000
ALKALINITY         24.0000       52.0000       35.0000        6.0000       20.0000       20.0000       20.0000       20.0000
CHLORIDE           10.0000       21.0000        8.0000       16.0000       20.0000       20.0000       16.0000       17.0000
COD                 1.0000        1.0000        5.0000        8.0000        6.0000        2.0000        2.0000        3.0000
COND              370.0000      450.0000      710.0000      170.0000      120.0000      110.0000      260.0000      160.0000
TDS               250.0000      310.0000      560.0000      120.0000      180.0000       90.0000      160.0000      130.0000
TSS                 9.0000      180.0000       13.0000       56.0000     2400.0000       79.0000       59.0000       64.0000
SULFATE           110.0000      150.0000      360.0000       28.0000       50.0000       12.0000       40.0000       24.0000
ARSENIC       <      .0020  <      .0020  <      .0020         .0020         .0080         .0030  <      .0020  <      .0020
BORON                .3000         .4200         .4100         .1700         .1900         .2800         .1700         .0700
CALCIUM             2.0000       38.0000      130.0000       17.0000        8.5000        8.1000       13.0000       10.0000
LEAD                 .0290         .0240  <      .0100  <      .0100         .0800         .0400         .0200         .0110
MAGNESIUM          14.0000       19.0000       26.0000        4.1000        3.6000        2.9000        3.7000        3.3000
MERCURY       <      .0002  <      .0002  <      .0002  <      .0002  <      .0002  <      .0002  <      .0002  <      .0002
SELENIUM      <      .0010  <      .0010  <      .0010  <      .0010         .0060  <      .0010  <      .0010         .0020
SULFITE             0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM             14.0000       15.0000        8.9000        9.4000        8.7000       20.0000       14.0000       13.0000
TOTAL ELEM        150.4122      243.4472      533.3232       74.6832       91.2842       63.3242       94.8932       67.3852
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POND G GROUND WELL 1

WELL DESIG           GWG1         GWG1
DATE          800518.0000  800702.0000
REC NO.        17580.0000   18120.0000
PH                 6.3000       6.6000
ALKALINITY        21.0000      19.0000
CHLORIDE          14.0000      64.0000
COD                8.0000       3.0000
COND             140.0000     120.0000
TDS              110.0000     170.0000
TSS               60.0000      67.0000
SULFATE           19.0000       6.0000
ARSENIC             .0030 <      .0020
BORON               .0800 <      .0100
CALCIUM            9.9000       4.9000
LEAD                .0080        .0080
MAGNESIUM          3.2000       2.1000
MERCURY      <      .0002 <      .0002
SELENIUM     <      .0010 <      .0010
SULFITE            0.0000       0.0000
SODIUM            13.0000      12.0000
TOTAL ELEM        59.1922      89.0212
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POND G GROUND WELL 1--- AEROSPACE ---

WELL DESIG           GWG1         GWG1         GWG1         GWG1
DATE          770505.0000  780309.0000  780316.0000  790314.0000
REC NO.        12800.0000   12820.0000   12840.0000   12860.0000
PH                 6.8000       7.5600       7.8100       6.7000
ALKALINITY        20.0000       0.0000      13.0000       3.2000
CHLORIDE          38.0000      15.0000      11.0000      15.0000
COD                0.0000       0.0000       0.0000       0.0000
COND             140.0000     146.0000     154.0000     298.0000
TDS              116.0000     156.0000     120.0000     238.0000
TSS                0.0000       0.0000       0.0000       0.0000
SULFATE           36.0000      31.0000      30.0000     127.0000
ARSENIC             .0050 <      .0040       0.0000        .0300
BORON        <      .0500 <      .5000       1.6000        .5000
CALCIUM            8.0000       6.8000       7.0000      50.0000
LEAD                .0500        .2000       0.0000 <      .0900
MAGNESIUM          3.5000       5.0000       5.1000      15.0000
MERCURY      <      .0001        .0010       0.0000        .0020
SELENIUM            .0020        .0001       0.0000        .0060
SULFITE            0.0000       0.0000       0.0000       0.0000
SODIUM            13.0000      11.0000      11.0000      12.0000
TOTAL ELEM        98.6071      69.5051      65.7000     219.6280
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POND G GROUND WELL 2

WELL DESIG          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2
DATE         760914.0000   761115.0000   770505.0000   770707.0000   771216.0000   780316.0000   780511.0000   780628.0000
REC NO.       12880.0000    12900.0000    12920.0000    12940.0000    12960.0000    12980.0000    13000.0000    13020.0000
PH                6.7000        6.3000        7.2000        7.2000        6.7000        6.7000        6.7000        7.3000
ALKALINITY       94.0000       34.0000       56.0000       62.0000       70.0000       48.0000       80.0000       84.0000
CHLORIDE        120.0000       45.0000      220.0000      200.0000      220.0000      270.0000      280.0000      330.0000
COD              12.0000        0.0000       14.0000       18.0000       38.0000       12.0000       40.0000       18.0000
COND            760.0000      630.0000      900.0000      790.0000      930.0000     1100.0000     1300.0000     1500.0000
TDS             580.0000      530.0000      610.0000      590.0000      580.0000      650.0000     1100.0000      970.0000
TSS             920.0000      590.0000      110.0000      370.0000    30000.0000      100.0000     9800.0000     4700.0000
SULFATE         200.0000      280.0000      140.0000      100.0000       55.0000       46.0000       58.0000       19.0000
ARSENIC     <      .0050  <      .0020        .0180         .0070         .0080         .0460         .0820         .0280
BORON              .2200         .2400         .2200         .1500         .1100         .1200         .3800         .6000
CALCIUM          58.0000       50.0000       81.0000       72.0000      100.0000       51.0000       91.0000       79.0000
LEAD               .0340         .0500         .0200         .0100         .1400         .0170         .0450         .0420
MAGNESIUM         5.7000       22.0000       30.0000       28.0000       40.0000       13.0000       35.0000       27.0000
MERCURY     <      .0002         .0007  <      .0002  <      .0002         .0008  <      .0002         .0006         .0002
SELENIUM           .0010  <      .0010  <      .0020         .0010  <      .0020  <      .0020         .0030         .0070
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           86.0000       88.0000       85.0000       80.0000       78.0000      100.0000      120.0000      140.0000
TOTAL ELEM      469.9602      485.2937      556.2602      480.1682      493.2608      480.1852      584.5106      595.6772
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POND 6 GROUND WELL 2

WELL DESIG          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2          GWG2
DATE         780821.0000   790129.0000   790309.0000   790522.0000   790711.0000   790912.0000   791118.0000   800114.0000
REC NO.       13040.0000    13060.0000    13080.0000    13100.0000    15800.0000    15820.0000    15240.0000    15260.0000
PH                7.4000        7.1000        7.1000        6.8000        6.6000        6.9000        7.0000        6.8000
ALKALINITY       76.0000      120.0000      120.0000      190.0000      100.0000      110.0000       66.0000       72.0000
CHLORIDE        310.0000      110.0000      160.0000      270.0000      280.0000      330.0000      300.0000      180.0000
COD              38.0000        0.0000        8.0000       18.0000        9.0000        6.0000        8.0000        6.0000
COND           1300.0000      860.0000      940.0000     1300.0000     1200.0000     1200.0000     1200.0000      930.0000
TDS             820.0000      530.0000      580.0000      740.0000      800.0000      770.0000      700.0000      630.0000
TSS            1900.0000      260.0000     1000.0000      220.0000       89.0000     1800.0000       31.0000      370.0000
SULFATE          33.0000      180.0000      210.0000       94.0000       24.0000       52.0000       32.0000      130.0000
ARSENIC     <      .0020         .0030         .0040         .0090  <      .0020         .0100         .0040  <      .0020
BORON              .2500         .1600        2.4000         .2500        1.6000         .4000         .1200         .1400
CALCIUM          70.0000        9.4000       49.0000      100.0000       81.0000       72.0000      140.0000       78.0000
LEAD               .0780         .0600         .0230         .0530  <      .0100         .0800         .0160  <      .0100
MAGNESIUM        26.0000        4.4000       24.0000       28.0000       29.0000       24.0000       28.0000       24.0000
MERCURY     <      .0002         .0002         .0002  <      .0002  <      .0002  <      .0002  <      .0002  <      .0002
SELENIUM           .0040  <      .0020         .0040         .0180         .0160         .0130         .0090         .0080
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM          120.0000       98.0000      100.0000      120.0000      140.0000      150.0000      110.0000      160.0000
TOTAL ELEM      559.3342      402.0252      545.4312      612.3302      555.6282      628.5032      610.1492      572.1602
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POND G GROUND WELL 2

WELL DESIG          GWG2         GWG2         GWG2
DATE         800314.0000  800518.0000  800702.0000
REC NO.       17080.0000   17600.0000   18140.0000
PH                7.2000       6.8000       7.4000
ALKALINITY       79.0000     160.0000     160.0000
CHLORIDE        170.0000     190.0000      64.0000
COD              17.0000      16.0000      12.0000
COND           1300.0000    1300.0000    1500.0000
TDS             870.0000     710.0000     810.0000
TSS             280.0000      71.0000      65.0000
SULFATE         310.0000     110.0000     210.0000
ARSENIC      <     .0020  <     .0020  <     .0020
BORON              .0800        .1200        .2400
CALCIUM         100.0000     110.0000     110.0000
LEAD               .0160        .0050        .0090
MAGNESIUM        37.0000      25.0000      32.0000
MERCURY      <     .0002  <     .0002        .0002
SELENIUM           .0060        .0190        .0160
SULFITE           0.0000       0.0000       0.0000
SODIUM          100.0000     110.0000     110.0000
TOTAL ELEM      717.1042     545.1462     526.2672
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POND G GROUND WELL 2--- AEROSPACE ---

WELL DESIG          GWG2         GWG2         GWG2         GWG2
DATE         761115.0000  770505.0000  780309.0000  780316.0000
REC NO.       13120.0000   13140.0000   13160.0000   13180.0000
PH                7.3700       7.2900       7.7000       7.7200
ALKALINITY       30.0000      57.4000      46.0000      40.6000
CHLORIDE         92.0000     255.0000     180.0000     400.0000
COD               0.0000       0.0000       0.0000       0.0000
COND            680.0000     920.0000     943.0000     926.0000
TDS             446.0000     556.0000     574.0000     544.0000
TSS               0.0000       0.0000       0.0000       0.0000
SULFATE         240.0000     140.0000      64.0000      68.0000
ARSENIC      <     .0010        .0050  <     .0040       0.0000
BORON             1.6000       1.2000  <     .5000       3.0000
CALCIUM          48.0000      73.0000      59.0000      53.0000
LEAD               .0300        .0500        .2000       0.0000
MAGNESIUM        17.5000      25.9000      31.0000      26.0000
MERCURY      <     .0001  <     .0001        .0015       0.0000
SELENIUM     <     .0006        .0040        .0001       0.0000
SULFITE           0.0000       0.0000       0.0000       0.0000
SODIUM           80.0000      85.0000     100.0000     100.0000
TOTAL ELEM      479.1317     580.1591     434.7056     650.0000
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POND H RUNOFF

WELL DESIG	PRH	PRH	PRH	PRH	PRH	PRH	PRH	PRH
DATE	771122.0000	771201.0000	771220.0000	791108.0000	800111.0000	800317.0000	800518.0000	800701.0000
REC NO.	13200.0000	13220.0000	13240.0000	16780.0000	16800.0000	17300.0000	17800.0000	18200.0000
PH	7.6000	7.3000	7.7000	7.0000	6.9000	7.4000	7.1000	7.0000
ALKALINITY	36.0000	1200.0000	490.0000	100.0000	24.0000	280.0000	25.0000	560.0000
CHLORIDE	760.0000	44.0000	100.0000	40.0000	4.0000	5.0000	7.0000	6.0000
COD	12.0000	16.0000	12.0000	6.0000	8.0000	13.0000	23.0000	60.0000
COND	3200.0000	2400.0000	2400.0000	2300.0000	2200.0000	2300.0000	2400.0000	2700.0000
TDS	3200.0000	2500.0000	2500.0000	2400.0000	2100.0000	2200.0000	2100.0000	2300.0000
TSS	13.0000	2300.0000	2500.0000	8.0000	230.0000	360.0000	150.0000	1300.0000
SULFATE	1500.0000	1500.0000	1500.0000	160.0000	2000.0000	1500.0000	1400.0000	1500.0000
ARSENIC	.0020	.0880	.0780	.0180	.0350	.0270	.1100	.4900
BORON	30.0000	3.9000	6.6000	.1600	1.8000	.4400	1.2000	.7000
CALCIUM	820.0000	780.0000	760.0000	530.0000	830.0000	630.0000	730.0000	670.0000
LEAD	.0100	.0270	0.0000	.0320	.0150	.0170	.0300	.0160
MAGNESIUM	140.0000	39.0000	31.0000	32.0000	12.0000	12.0000	4.9000	8.4000
MERCURY	.0002	.0150	.0012	< .0002	.0011	.0007	< .0002	< .0002
SELENIUM	.0010	.0550	.0780	.0180	.0220	.0210	.0250	.0100
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	14.0000	4.5000	4.0000	2.9000	1.8000	1.3000	1.0000	1.9000
TOTAL ELEM	3264.0132	2371.5850	2401.7572	765.1282	2849.6731	2148.8057	2144.2652	2187.5162

POND H RUNOFF --- AEROSPACE ---

WELL DESIG	PRH	PRH	PRH	PRH	PRH	PRH	PRH	PRH
DATE	771122.0000	771214.0000	771220.0000	780314.0000	780323.0000	780404.0000	780420.0000	780425.0000
REC NO.	13260.0000	13280.0000	13300.0000	13320.0000	13340.0000	13360.0000	13380.0000	13400.0000
PH	7.5900	7.3000	7.5300	0.0000	0.0000	0.0000	0.0000	0.0000
ALKALINITY	32.0000	56.0000	22.0000	58.0000	54.8000	63.2000	41.0000	65.4000
CHLORIDE	390.0000	135.0000	175.0000	500.0000	45.0000	7.0000	13.0000	27.0000
COD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COND	2860.0000	2060.0000	2160.0000	2600.0000	2000.0000	1870.0000	1980.0000	1980.0000
TDS	2900.0000	2350.0000	2397.0000	2934.0000	2220.0000	2069.0000	2216.0000	2156.0000
TSS	0.0000	0.0000	0.0000	3.6000	14.4000	50.4000	11.6000	309.4000
SULFATE	1625.0000	1500.0000	1525.0000	1475.0000	1475.0000	1275.0000	1450.0000	1325.0000
ARSENIC	.0160	.0190	< .0100	.0330	.0250	.0250	.0250	.0330
BORON	20.0000	80.0000	11.0000	27.0000	10.0000	1.3000	< .5000	1.7000
CALCIUM	660.0000	570.0000	610.0000	630.0000	550.0000	520.0000	550.0000	580.0000
LEAD	.1100	.0900	.0900	.3000	.4000	< .2000	.4000	.3000
MAGNESIUM	113.0000	27.0000	24.0000	159.0000	30.1000	14.8000	13.1000	12.7000
MERCURY	.0030	.0040	.0020	.0008	.0027	.0011	.0019	.0007
SELENIUM	.0030	.0220	.0100	.0006	.0008	.0001	.0004	.0001
SULFITE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SODIUM	13.0000	4.0000	3.8000	13.0000	3.6000	3.5000	2.4000	2.6000
TOTAL ELEM	2821.1320	2316.1350	2348.9120	2804.3344	2114.1285	1821.8262	2029.4273	1949.3338

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POND H RUNOFF       --- AEROSPACE ---

WELL DESIG         PRH          PRH          PRH          PRH          PRH          PRH          PRH
DATE        780516.0000  780523.0000  780628.0000  790731.0000  790828.0000  790921.0000  791108.0000
REC NO.      13420.0000   13440.0000   13460.0000   16480.0000   16500.0000   16520.0000   16580.0000
PH               0.0000       0.0000       0.0000       7.5800       6.8700       6.9500       7.1000
ALKALINITY      46.4000      44.0000     122.4000       6.0000      68.0000      42.2000      98.0000
CHLORIDE         5.6000       7.0000      90.0000       9.0000      26.0000      12.0000      45.0000
COD              0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
COND          1920.0000    1960.0000    1940.0000    1520.0000    2020.0000    1580.0000    2060.0000
TDS           2134.0000    2242.0000    2653.0000    1662.0000    2248.0000    1782.0000    2276.0000
TSS              4.8000       8.2000      64.6000       0.0000       0.0000       0.0000       0.0000
SULFATE       1325.0000    1450.0000    1500.0000    1250.0000    1550.0000    1400.0000    1300.0000
ARSENIC          0.0000        .0160        .0250        .0100        .0080        .0100        .0090
BORON             .7000       1.4000       9.0000       1.4000       2.7000        .7000       3.0000
CALCIUM        570.0000     600.0000     700.0000     310.0000     400.0000     320.0000     430.0000
LEAD             0.0000        .2800  <     .2000        .0800        .0200        .0600        .0500
MAGNESIUM       11.4000       5.1000      36.2000       9.1000      18.9000      11.6000      34.0000
MERCURY          0.0000        .0013        .0010  <     .0002  <     .0002  <     .0002  <     .0002
SELENIUM         0.0000        .0003        .0001        .0030        .0010        .0050        .0040
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM           2.6000        .9000      11.1000       3.0000       3.2000       2.0000       6.0000
TOTAL ELEM    1915.3000    2064.6976    2346.5261    1582.5932    2000.8292    1746.3752    1818.0632
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POND H UNDERDRAIN

WELL DESIG           UDH         UDH         UDH         UDH         UDH         UDH         UDH         UDH
DATE         770819.0000 770820.0000 770821.0000 770822.0000 770823.0000 770824.0000 770826.0000 770828.0000
REC NO.       13480.0000  13500.0000  13520.0000  13540.0000  13560.0000  13580.0000  13600.0000  13620.0000
PH                7.1000      7.0000      7.0000      7.0000      7.0000      7.1000      7.1000      7.1000
ALKALINITY       38.0000     54.0000     48.0000     52.0000     54.0000     54.0000     54.0000     54.0000
CHLORIDE       2800.0000   3200.0000   3200.0000   3300.0000   3400.0000   3300.0000   2800.0000   2600.0000
COD             120.0000    140.0000    120.0000    140.0000    120.0000    130.0000    140.0000    140.0000
COND          10000.0000  11000.0000  12000.0000  11000.0000  12000.0000  12000.0000  10000.0000  10000.0000
TDS            9400.0000   9900.0000   9000.0000   9200.0000   9600.0000   9000.0000   9700.0000   9400.0000
TSS              86.0000    290.0000     56.0000     43.0000     37.0000     35.0000     21.0000     23.0000
SULFATE        1600.0000   1600.0000   1600.0000   1600.0000   1600.0000   1700.0000   1900.0000   1800.0000
ARSENIC      <     .0040       .0160 <     .0040 <     .0040 <     .0040 <     .0040 <     .0020 <     .0020
BORON           110.0000    180.0000    140.0000    130.0000    190.0000    110.0000    190.0000    200.0000
CALCIUM        1600.0000   1700.0000   1600.0000   1700.0000   1600.0000   1600.0000   1500.0000   1400.0000
LEAD         <     .0100       .0230 <     .0100 <     .0100 <     .0100 <     .0100 <     .0100 <     .0100
MAGNESIUM       560.0000    620.0000    660.0000    690.0000    700.0000    730.0000    680.0000    670.0000
MERCURY      <     .0002       .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM           .1700       .1600       .1600       .1900       .1900       .2000       .1500       .0250
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           77.0000     71.0000     81.0000     81.0000     82.0000     87.0000     75.0000     69.0000
TOTAL ELEM     6747.1842   7371.1992   7281.1742   7501.2042   7572.2042   7527.2142   7145.1622   6739.0372
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POND H UNDERDRAIN

WELL DESIG           UDH         UDH         UDH         UDH         UDH         UDH         UDH         UDH
DATE         770830.0000 770901.0000 770902.0000 770906.0000 770912.0000 770926.0000 771004.0000 771011.0000
PEC NO.       13640.0000  13660.0000  13680.0000  13700.0000  13720.0000  13740.0000  13760.0000  13780.0000
PH                7.1000      7.1000      7.1000      7.3000      7.5000      7.3000      7.5000      7.8000
ALKALINITY       54.0000     57.0000     50.0000     65.0000     69.0000     86.0000     92.0000    100.0000
CHLORIDE       2300.0000   2200.0000   2300.0000   2100.0000   2200.0000   1800.0000   1800.0000   1900.0000
COD             140.0000     76.0000    120.0000     74.0000    110.0000    110.0000     90.0000     90.0000
COND           9300.0000   9100.0000   9000.0000   8700.0000   8600.0000   7900.0000   8000.0000   7800.0000
TDS            8900.0000   8700.0000   7400.0000   7200.0000   7100.0000   6700.0000   6700.0000   6600.0000
TSS              18.0000     20.0000     19.0000     17.0000     15.0000     14.0000     18.0000     15.0000
SULFATE        1900.0000   1800.0000   1800.0000   1800.0000   1800.0000   1700.0000   1800.0000   1700.0000
ARSENIC      <     .0020 <     .0020 <     .0020 <     .0020 <     .0020 <     .0020 <     .0020 <     .0020
BORON           180.0000     80.0000     93.0000    110.0000     97.0000     86.0000     98.0000     86.0000
CALCIUM        1300.0000   1300.0000   1200.0000   1300.0000   1100.0000   1200.0000   1200.0000   1100.0000
LEAD         <     .0100 <     .0100 <     .0100 <     .0100 <     .0100 <     .0100 <     .0100 <     .0100
MAGNESIUM       600.0000    580.0000    620.0000    540.0000    530.0000    470.0000    450.0000    450.0000
MERCURY      <     .0002 <     .0002 <     .0002 <     .0002 <     .0002      0.0000 <     .0002 <     .0002
SELENIUM           .1400       .1500       .1800       .1100       .1400       .0320       .0740       .0740
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           50.0000     50.0000     37.0000     36.0000     36.0000     34.0000     34.0000     35.0000
TOTAL ELEM     6330.1522   6010.1622   6050.1922   5886.1222   5763.1522   5290.0440   5382.0862   5271.0862
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POND H UNDERDRAIN

WELL DESIG            UDH           UDH           UDH           UDH           UDH           UDH           UDH           UDH
DATE          771104.0000   771122.0000   780316.0000   780511.0000   780628.0000   780821.0000   781211.0000   790731.0000
REC NO.        13800.0000    13820.0000    13840.0000    13860.0000    13880.0000    13900.0000    13920.0000    16200.0000
PH                 7.8000        7.4000        0.0000        7.5000        7.6000        7.8000        6.7000        7.0000
ALKALINITY       120.0000      140.0000        0.0000      260.0000      180.0000      180.0000      130.0000      140.0000
CHLORIDE        2000.0000     1900.0000        0.0000     2100.0000      810.0000      730.0000     1900.0000     1500.0000
COD               90.0000       84.0000       29.0000       33.0000        9.0000       30.0000       59.0000       50.0000
COND            7800.0000     7600.0000        0.0000     4900.0000     4100.0000     4300.0000     8200.0000     7100.0000
TDS             7100.0000     6700.0000        0.0000     3700.0000     3500.0000     3700.0000     7200.0000     6400.0000
TSS               29.0000       11.0000        0.0000      130.0000      720.0000        6.0000       32.0000       42.0000
SULFATE         1800.0000     1800.0000        0.0000     1200.0000     1700.0000     1200.0000     1700.0000     1800.0000
ARSENIC       <     .0040         .0020         .0040         .0060         .0060         .0050         .0030         .0030
BORON             88.0000      120.0000        0.0000       47.0000       22.0000       58.0000       74.0000        2.0000
CALCIUM         1400.0000     1000.0000      490.0000      690.0000      680.0000      670.0000     1100.0000     1100.0000
LEAD          <     .0100         .0100 <       .0100         .0320         .0300 <       .0100         .2100 <       .0100
MAGNESIUM        510.0000      440.0000       23.0000      320.0000      270.0000      260.0000      560.0000      430.0000
MERCURY       <     .0002         .0002 <       .0002         .0014         .0004 <       .0002 <       .0002 <       .0002
SELENIUM            .0410         .0230         .0090         .0140         .0100         .0130         .0390         .0130
SULFITE            0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            44.0000       60.0000       46.0000       49.0000       44.0000       59.0000       59.0000       82.0000
TOTAL ELEM      5842.0552     5320.0352      559.0232     4406.0534     3526.0464     2977.0282     5393.2522     4914.0262
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POND H UNDERDRAIN

WELL DESIG            UDH           UDH           UDH
DATE          791113.0000   800114.0000   800314.0000
REC NO.        15280.0000    15300.0000    17360.0000
PH                 6.9000        6.7000        6.9000
ALKALINITY       160.0000      100.0000       75.0000
CHLORIDE        1600.0000      980.0000      420.0000
COD               26.0000       18.0000       32.0000
COND            6100.0000     4900.0000     4200.0000
TDS             5600.0000     4200.0000     3800.0000
TSS               38.0000      330.0000        6.0000
SULFATE         1550.0000     1700.0000     1600.0000
ARSENIC             .0070         .0050         .0190
BORON             90.0000       48.0000       38.0000
CALCIUM         1400.0000      890.0000      790.0000
LEAD                .0220 <       .0100 <       .0100
MAGNESIUM        460.0000      320.0000       22.0000
MERCURY       <     .0002         .0005 <       .0002
SELENIUM            .0470         .0380         .0220
SULFITE            0.0000        0.0000        0.0000
SODIUM            42.0000       28.0000       25.0000
TOTAL ELEM      5142.0762     3966.0535     2895.0512
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POND H UNDERDRAIN   --- AEROSPACE ---

WELL DESIG            UDH           UDH           UDH           UDH           UDH           UDH           UDH
DATE          770505.0000   771115.0000   771122.0000   780309.0000   780316.0000   790327.0000   791113.0000
REC NO.        13940.0000    13960.0000    13980.0000    14000.0000    14020.0000    14040.0000    16560.0000
PH                 7.6100        7.6000        7.2100        7.7000        7.8200        6.6000        6.5600
ALKALINITY       128.0000      123.0000      140.0000      279.0000      154.0000       84.0000      136.4000
CHLORIDE         105.0000     1500.0000     1750.0000     1350.0000      240.0000     1450.0000     1600.0000
COD                0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
COND             610.0000     7140.0000     6760.0000     3600.0000     1520.0000     5050.0000     5710.0000
TDS              418.0000     6044.0000     5690.0000     2928.0000     1198.0000     4264.0000     4978.0000
TSS                0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SULFATE          147.0000     2000.0000     1625.0000     1025.0000      440.0000     1150.0000     1550.0000
ARSENIC            0.0000  <      .0100  <      .0100         .0120        0.0000  <      .0100         .0080
BORON       <       .0500       60.0000       80.0000       36.0000        1.2000       57.0000       90.0000
CALCIUM           53.0000     1070.0000     1040.0000      490.0000      140.0000      580.0000      620.0000
LEAD               0.0000         .2100         .1900         .6000        0.0000         .1500         .0800
MAGNESIUM         12.3000      530.0000      500.0000      298.0000       41.0000      372.0000      534.0000
MERCURY            0.0000         .0030         .0050         .0017        0.0000         .0060  <      .0002
SELENIUM           0.0000         .0020         .0170         .0003        0.0000         .0200         .0030
SULFITE            0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM            70.0000       52.0000       47.0000       55.0000       85.0000       38.0000       52.0000
TOTAL ELEM       387.3500     5212.2250     5042.2220     3254.6140      947.2000     3647.1860     4446.0912
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POND H GROUND WELL 1

WELL DESIG          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1
DATE         770505.0000   770707.0000   770926.0000   771104.0000   771216.0000   780316.0000   780511.0000   780628.0000
REC NO.       14060.0000    14080.0000    14100.0000    14120.0000    14140.0000    14160.0000    14180.0000    14200.0000
PH                6.6000        7.4000        7.7000        7.5000        7.0000        6.9000        7.0000        7.2000
ALKALINITY      130.0000      100.0000      120.0000      110.0000      110.0000       13.0000      100.0000       72.0000
CHLORIDE         38.0000       18.0000       15.0000       16.0000       14.0000       94.0000       72.0000       64.0000
COD             110.0000        8.0000       32.0000        3.0000        0.0000        3.0000        5.0000        2.0000
COND            440.0000      370.0000      460.0000      430.0000      400.0000      590.0000      480.0000      370.0000
TDS             310.0000      290.0000      440.0000      320.0000      330.0000      360.0000      390.0000      360.0000
TSS             230.0000       40.0000     1600.0000      590.0000     2500.0000      810.0000     1000.0000     2100.0000
SULFATE          58.0000       79.0000       91.0000       87.0000       68.0000       19.0000       30.0000       15.0000
ARSENIC            .0070 <       .0020         .0220         .0040 <       .0020 <       .0020         .0110         .0080
BORON              .1700         .0200         .0600         .0400         .0500         .1000         .1300         .1000
CALCIUM          30.0000       36.0000       48.0000       46.0000       36.0000       33.0000       37.0000       28.0000
LEAD               .0150         .0100         .0600         .0340         .0800 <       .0100         .0180 <       .0100
MAGNESIUM        14.0000       11.0000       16.0000       13.0000       15.0000       10.0000       12.0000        9.3000
MERCURY    <       .0002 <       .0002         .0004         .0004         .0007 <       .0002 <       .0002 <       .0002
SELENIUM           .0040         .0010 <       .0020         .0020 <       .0020 <       .0020         .0010 <       .0010
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           45.0000       33.0000       36.0000       36.0000       34.0000       34.0000       47.0000       37.0000
TOTAL ELEM      185.1962      177.0332      206.1444      198.0804      167.1347      190.1142      198.1602      153.4192


POND H GROUND WELL 1

WELL DESIG          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1          GWH1
DATE         780821.0000   790122.0000   790312.0000   790524.0000   790711.0000   790912.0000   791113.0000   800114.0000
REC NO.       14220.0000    14240.0000    14260.0000    14280.0000    15840.0000    15860.0000    15320.0000    15340.0000
PH                6.8000        6.6000        6.6000        6.6000        7.0000        6.6000        7.0000        6.8000
ALKALINITY       74.0000      140.0000      140.0000      120.0000       49.0000       46.0000       57.0000       60.0000
CHLORIDE         70.0000       92.0000       85.0000      130.0000       60.0000       46.0000       50.0000       50.0000
COD               9.0000        7.0000        0.0000        3.0000       38.0000        2.0000        3.0000        2.0000
COND            370.0000      600.0000      570.0000      550.0000      320.0000      250.0000      260.0000      410.0000
TDS             280.0000      350.0000      370.0000      440.0000      260.0000      240.0000      190.0000      200.0000
TSS             290.0000      740.0000      960.0000      330.0000      380.0000     1700.0000      140.0000      230.0000
SULFATE           6.0000        9.0000        8.0000       59.0000       12.0000 <      4.0000       32.0000        2.0000
ARSENIC            .0020 <       .0020 <       .0020         .0130         .0110         .0130 <       .0020 <       .0020
BORON              .0800         .1200         .2200         .3100        1.6000         .3500         .0400        5.6000
CALCIUM          19.0000       33.0000       33.0000       42.0000       16.0000       10.0000       11.0000       11.0000
LEAD               .0350         .0150         .0780         .0430 <       .0100         .0500         .1600 <       .0100
MAGNESIUM         7.7000       14.0000       16.0000       19.0000        6.7000        6.9000        4.1000        3.8000
MERCURY            .0002         .0003 <       .0002 <       .0002 <       .0002 <       .0002 <       .0002 <       .0002
SELENIUM           .0010         .0010 <       .0010         .0020         .0020         .0020         .0020         .0020
SULFITE           0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000        0.0000
SODIUM           48.0000       73.0000       74.0000       53.0000       37.0000       31.0000       41.0000      150.0000
TOTAL ELEM      150.8182      221.1383      216.3012      303.3682      133.3232       98.3152      133.3042      222.4142
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POND M GROUND WELL 1


WELL DESIG          GWM1        GWM1        GWM1
DATE         800314.0000 800518.0000 800702.0000
REC NO.       17100.0000  17620.0000  18160.0000
PH                6.8000      6.8000      7.0000
ALKALINITY       95.0000     66.0000     38.0000
CHLORIDE         50.0000     84.0000     75.0000
COD               7.0000      2.0000      3.0000
COND            420.0000    480.0000    360.0000
TDS             260.0000    180.0000    200.0000
TSS             360.0000     27.0000     21.0000
SULFATE           6.0000     15.0000      5.0000
ARSENIC      <     .0020 <     .0020       .0070
BORON              .1600       .9000       .0200
CALCIUM          17.0000     24.0000     11.0000
LEAD               .0320       .0020       .0170
MAGNESIUM         6.5000      8.0000      4.7000
MERCURY      <     .0002 <     .0002 <     .0002
SELENIUM     <     .0010       .0010 <     .0010
SULFITE           0.0000      0.0000      0.0000
SODIUM           54.0000     51.0000     44.0000
TOTAL ELEM      133.6952    183.7052    139.7452


POND M GROUND WELL 1--- AEROSPACE ---


WELL DESIG          GWM1        GWM1        GWM1        GWM1        GWM1
DATE         770505.0000 780309.0000 780316.0000 790314.0000 791113.0000
REC NO.       14300.0000  14320.0000  14340.0000  14360.0000  16540.0000
PH                6.6100      8.1100      8.1400      7.3000      6.5300
ALKALINITY      133.0000     92.0000    109.0000    146.6000     54.0000
CHLORIDE         82.0000     30.0000     36.0000    135.0000     72.0000
COD               0.0000      0.0000      0.0000      0.0000      0.0000
COND            420.0000    372.0000    382.0000    500.0000    244.0000
TDS             296.0000    316.0000    288.0000    300.0000    124.0000
TSS               0.0000      0.0000      0.0000      0.0000      0.0000
SULFATE          58.0000     71.0000     75.0000    175.0000      7.0000
ARSENIC            .0040       .0030      0.0000       .0100       .0100
BORON        <     .0500 <     .5000 <     .5000       .3000 <     .5000
CALCIUM          35.0000     26.0000     23.0000     80.0000      9.0000
LEAD               .0550       .1600      0.0000 <     .0900       .0100
MAGNESIUM        11.2000     12.0000     12.0000     16.0000      5.1000
MERCURY      <     .0001       .0008      0.0000       .0013 <     .0002
SELENIUM           .0006       .0003      0.0000       .0200       .0060
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           45.0000     35.0000     32.0000     64.0000     43.0000
TOTAL ELEM      231.3097    174.6691    178.5000    470.4213    136.6262
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POND H GROUND WELL 2

WELL DESIG          GWH2        GWH2        GWH2        GWH2        GWH2        GWH2        GWH2        GWH2
DATE         760914.0000 770505.0000 771216.0000 780316.0000 780511.0000 780628.0000 780821.0000 790123.0000
REC NO.       14380.0000  14400.0000  14420.0000  14440.0000  14460.0000  14480.0000  14500.0000  14520.0000
PH                7.1000      6.6000      6.9000      6.7000      6.6000      7.3000      6.7000      6.6000
ALKALINITY      170.0000    150.0000    120.0000     68.0000    120.0000     60.0000     49.0000    170.0000
CHLORIDE         98.0000     82.0000     76.0000     88.0000     98.0000    100.0000    100.0000     74.0000
COD              30.0000      9.0000     42.0000      8.0000      3.0000      5.0000      9.0000      8.0000
COND            590.0000    550.0000    570.0000    640.0000    550.0000    470.0000    430.0000    650.0000
TDS             400.0000    370.0000    450.0000    400.0000    350.0000    320.0000    290.0000    350.0000
TSS              71.0000     91.0000   4200.0000    940.0000   4800.0000   3900.0000    360.0000   4300.0000
SULFATE          39.0000     48.0000 <   20.0000     14.0000 <    1.0000      9.0000      5.0000     18.0000
ARSENIC     <      .0050       .0040       .0020 <     .0020       .0210 <     .0040       .0220 <     .0020
BORON              .1400       .2000       .0800       .2100       .0800       .1600       .1200       .1000
CALCIUM          72.0000     39.0000     35.0000     34.0000     48.0000     30.0000     27.0000     30.0000
LEAD               .0480       .0650       .1700       .0330       .0550       .0560       .0410       .0630
MAGNESIUM        22.0000     14.0000     19.0000     12.0000     21.0000     13.0000     12.0000     16.0000
MERCURY     <      .0002 <     .0002       .0005 <     .0002       .0006       .0010 <     .0002 <     .0002
SELENIUM    <      .0010       .0020       .0020 <     .0020 <     .0010       .0020       .0020 <     .0010
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM            4.5000     70.0000     48.0000     43.0000     66.0000     36.0000     40.0000     84.0000
TOTAL ELEM      235.6942    253.2712    198.2545    191.2472    234.1576    188.2430    184.1852    222.1662


POND H GROUND WELL 2

WELL DESIG          GWH2        GWH2        GWH2        GWH2        GWH2        GWH2        GWH2        GWH2
DATE         790525.0000 790713.0000 790912.0000 791113.0000 800114.0000 800314.0000 800518.0000 800702.0000
REC NO.       14540.0000  15880.0000  15900.0000  15360.0000  15380.0000  17120.0000  17640.0000  18180.0000
PH                6.6000      6.9000      6.9000      7.2000      6.5000      7.0000      6.9000      7.0000
ALKALINITY      150.0000     62.0000     52.0000     56.0000     40.0000     70.0000     74.0000     50.0000
CHLORIDE        110.0000    100.0000     96.0000    100.0000     86.0000     83.0000    170.0000    110.0000
COD               8.0000     13.0000      3.0000      2.0000      2.0000     11.0000      8.0000     12.0000
COND            550.0000    490.0000    410.0000    440.0000    610.0000    480.0000    700.0000    540.0000
TDS             320.0000    360.0000    300.0000    310.0000    300.0000    470.0000    240.0000    340.0000
TSS            1800.0000    580.0000   4300.0000    480.0000    680.0000   1400.0000    530.0000     20.0000
SULFATE          15.0000      6.0000     11.0000      4.0000      7.0000     10.0000     10.0000      7.0000
ARSENIC            .0080       .0210       .0110 <     .0020 <     .0020 <     .0020       .0040 <     .0020
BORON              .1200       .1400       .0450 <     .0100       .1800       .0800       .0500       .0900
CALCIUM          32.0000     34.0000     28.0000     11.0000     31.0000     31.0000     42.0000     37.0000
LEAD               .0250       .0280       .0400       .0300 <     .0100       .0340       .0090       .0230
MAGNESIUM        18.0000     15.0000     12.0000      9.6000     12.0000     13.0000     17.0000     16.0000
MERCURY     <      .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002 <     .0002
SELENIUM           .0040       .0020       .0030       .0030       .0020       .0010       .0030       .0010
SULFITE           0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
SODIUM           55.0000     42.0000     33.0000     39.0000     44.0000     42.0000     54.0000     48.0000
TOTAL ELEM      227.1572    197.1912    180.1072    163.6452    180.1942    179.1172    293.0662    218.1162
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POND H GROUND WELL 2--- AEROSPACE ---

WELL DESIG           GWH2        GWH2        GWH2
DATE          770505.0000 780309.0000 780316.0000
REC NO.        14560.0000  14580.0000  14600.0000
PH                 7.3000      8.0300      8.2900
ALKALINITY       152.0000    140.0000    122.0000
CHLORIDE         110.0000    154.0000    125.0000
COD                0.0000      0.0000      0.0000
COND             540.0000    478.0000    472.0000
TDS              346.0000    316.0000    289.0000
TSS                0.0000      0.0000      0.0000
SULFATE           45.0000     12.0000      9.0000
ARSENIC     <       .0010       .0000      0.0000
BORON               .0500 <     .5000      1.4000
CALCIUM           39.0000     33.0000     28.0000
LEAD                .0400       .2000      0.0000
MAGNESIUM         12.2000     16.0000     14.0000
MERCURY     <       .0001       .0007      0.0000
SELENIUM    <       .0006       .0001      0.0000
SULFITE            0.0000      0.0000      0.0000
SODIUM            65.0000     52.0000     48.0000
TOTAL ELEM       271.2917    267.7088    225.4000
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POND J RUNOFF

WELL DESIG          PRJ          PRJ          PRJ          PRJ
DATE        791108.0000  800111.0000  800311.0000  800518.0000
REC NO.      16820.0000   16840.0000   17320.0000   17820.0000
PH               6.6000       6.8000       6.9000       7.0000
ALKALINITY      22.0000      21.0000      19.0000     470.0000
CHLORIDE        21.0000       6.0000      34.0000       1.0000
COD              3.0000       4.0000       4.0000     120.0000
COND          2100.0000    2100.0000    2200.0000    2600.0000
TDS           2300.0000    2100.0000    2100.0000    2400.0000
TSS              6.0000      17.0000       9.0000    1300.0000
SULFATE       1400.0000    1400.0000    1400.0000    1500.0000
ARSENIC           .0020        .0390        .0030        .1560
BORON            1.2000       3.4000        .1300       1.4000
CALCIUM        640.0000     680.0000     550.0000    1300.0000
LEAD              .0160 <      .0100 <      .0100        .0020
MAGNESIUM        4.9000       2.0000       2.5000      16.0000
MERCURY     <     .0002        .0003 <      .0002        .0021
SELENIUM          .0100        .0220        .0150        .0340
SULFITE          0.0000       0.0000       0.0000       0.0000
SODIUM           1.0000       1.1000        .5000       2.5000
TOTAL ELEM    2068.1282    2092.5713    1987.1582    2821.0941


POND J RUNOFF        --- AEROSPACE ---

WELL DESIG          PRJ          PRJ          PRJ          PRJ          PRJ          PRJ
DATE        790329.0000  790404.0000  790817.0000  790828.0000  790921.0000  791108.0000
REC NO.      16700.0000   16720.0000   16600.0000   16620.0000   16640.0000   16660.0000
PH               7.0000       6.0000       8.7400       6.4300       6.6600       6.8100
ALKALINITY      40.0000      22.0000      20.0000      15.0000      14.0000      18.6000
CHLORIDE        44.0000      25.0000      35.0000      25.0000      10.0000      21.0000
COD              0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
COND          2020.0000    1860.0000    1940.0000    2360.0000    1620.0000    1900.0000
TDS           2186.0000    2102.0000    2104.0000    2128.0000    1820.0000    2156.0000
TSS              0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SULFATE       1310.0000    1400.0000    1525.0000    1525.0000    1175.0000    1400.0000
ARSENIC          0.0000        .0400        .0200        .0300        .0100        .0100
BORON            2.6000       3.3000       3.5000       2.7000        .5000       2.0000
CALCIUM        410.0000     390.0000     440.0000     390.0000     295.0000     390.0000
LEAD             0.0000        .3100        .0600        .0700        .0300        .0500
MAGNESIUM       16.0000      12.0000      11.9000       8.4000       4.7000       5.7000
MERCURY          0.0000        .0007 <      .0001 <      .0002 <      .0002 <      .0002
SELENIUM         0.0000        .0320        .0060        .0050        .0070        .0040
SULFITE          0.0000       0.0000       0.0000       0.0000       0.0000       0.0000
SODIUM           1.6000       1.6000       2.6000       1.6000       1.3000       1.4000
TOTAL ELEM    1784.6000    1632.2827    2021.0061    1952.6052    1486.5472    1820.1642
```

```
POND K RUNOFF          --- AEROSPACE ---

WELL DESIG          PBK
DATE         790403.0000
REC NO.       16680.0000
PH                7.1000
ALKALINITY       25.0000
CHLORIDE         47.0000
COD               0.0000
COND           1920.0000
TDS            2207.0000
TSS               0.0000
SULFATE        1450.0000
ARSENIC            .0000
BORON             5.0000
CALCIUM         410.0000
LEAD               .4400
MAGNESIUM        27.0000
MERCURY            .0007
SELENIUM           .0070
SULFITE           0.0000
SODIUM            1.0000
TOTAL ELEM     1941.5277
```

APPENDIX E

METHODS USED TO DETERMINE CHEMICAL AND PHYSICAL CHARACTERISTICS OF FGD WASTES

E.1 METHODS OF CHEMICAL ANALYSIS USED BY AEROSPACE

This appendix describes the analytical techniques used by The Aerospace Corporation to determine the concentrations of constituents in the flue gas desulfurization (FGD) wastes and water samples.[*] The constituents present in the liquors and water samples are divided into the following: major chemical species (calcium, sulfate, chloride, and TDS), trace metal species, and additional chemical species. Other water quality tests are also described.

Consideration was given to the range of concentration of the constituents and to the corresponding costs of the analyses to obtain data having high precision and high accuracy.[†]

E.1.1 Major Chemical Species

Calcium Determination

Atomic absorption spectrophotometry is presently used for calcium analyses. Results for solutions analyzed by this method were in agreement with those obtained by an oxalate titrimetric method to within 10%.

Sulfate Determination

Standard nephelometry techniques were used for this analysis. A barium sulfate precipitate was formed by the reaction of the sulfate ion with a barium chloranilate reagent. The resulting turbidity was determined by a spectrophotometer and compared to a curve prepared from standard sulfate solutions. Although multiple dilutions are necessary to bring the concentration to a range of optimum reliability, the error is less than 10%.

---

[*] The methods used by TVA are given in: Methods for Chemical Analysis of Water and Wastes, Second Edition, Methods Development and Quality Assurance Research Laboratory, National Energy Research Center, Cincinnati (1974), and Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition, American Public Health Association, New York.

[†] Precision is defined as the relationship between a measured value and the statistical mean of measured values, and accuracy is the relationship between the true value and the mean measured value.

Chloride Determination

A specific ion electrode was used to determine the concentration of chloride ions. This method has a precision of about 1% and an accuracy of about 5%. Comparisons were made with results of titrations with silver nitrate. The chloride concentrations, measured with the electrode (1000 to 5000 ppm), in each case differed from the corresponding titration data by less than 5%.

Total Dissolved Solids (TDS) Determination

The TDS were determined gravimetrically by evaporating a 25-ml sample to a constant weight overnight in a tared weighing bottle at a temperature of about 180°C. Precision is about 2%, and accuracy is about 5%.

E.1.2 Trace Metal Species

Atomic absorption spectrophotometry was used for analyses of the following elements: aluminum, antimony, arsenic, cadmium, chromium, copper, cobalt, iron, manganese, mercury, molybdenum, nickel, lead, selenium, silicon, silver, tin, vanadium, and zinc. Results were verified by analyzing National Bureau of Standards (NBS) data. Precision and accuracy are dependent upon the means of activation, the specific element, its relative concentration, and the extent of interference by other elements and matrix effects. The precision and accuracy of the measurements of concentrations of all elements that exceed water quality reuse criteria ranged between 5 and 20%. However, the precision, with furnace activation, of trace metals occurring at very low levels is probably no better than 50%.

Mercury was also determined using this technique; however, the mercury was reduced to the elemental state with stannous chloride, and the absorption of the resulting mercury vapor was measured. This method has a precision of about 20% and an accuracy of about 50%.

E.1.3 Additional Chemical Species

Sodium Determination

Atomic absorption spectrophotometry or flame photometry was used to determine sodium ion concentations, depending on whether the concentrations were relatively low or high. Errors are typically less than 10%.

Sulfite Determination

Total sulfite was determined using a specific ion electrode, and no significant interferences were observed. The oxidation of the sulfite ion to sulfate is a very rapid reaction. Scrubber liquor protected from the atmosphere typically shows sulfite concentrations of several hundred milligrams per liter; however, a brief atmospheric exposure causes oxidation and reduces these concentrations by one or more orders of magnitude. The reported sulfite measurements were for samples analyzed immediately upon arrival in the laboratory. No specific action was taken to inhibit oxidation other than to ensure that the samples were transported to the analytical laboratory in sealed cotainers. The exposure to air during sampling, filtering, and measuring, however, resulted in the reduced concentrations reported.

Phosphate Determination

The phosphate analysis was determined by spectrophotometry methods, using ammonium molybdate to form the molybdenum blue complex.

Nitrogen Determination

Nitrogen was determined by the Kjeldahl method, which reduces nitrogen to ammonia with sodium thiosulfate. The ammonia was then distilled and the amount determined by titration. This method has a precision of about 10%, and accuracy at the levels of the concentrations determined is about 25%.

Fluoride Determination

The fluoride ion was determined by the specific ion electrode using a Beckman Model 4500 digital pH meter. There were no significant interferences. This method has a precision of about 5%, and accuracy of 20% is attainable at the low levels measured.

Boron Determination

Boron was determined spectrophotometrically with the Hach DR2 using the Carmine method.

Magnesium Determination

Magnesium was determined by atomic absorption spectrophotometry in the same manner as were the trace metals.

E.1.4 Other Water Quality Tests

Chemical Oxygen Demand

Chemical oxygen demand was determined by reacting the organics and sulfites present with potassium dichromate and measuring the reduced chromium by spectrophotometry. While a precision of 25% is attainable, accuracy depends on the same history (i.e., degree of exposure to atmospheric oxygen) and is about 100% for routine analysis.

Total Alkalinity

Total alkalinity was determined by titrating a 25-ml sample with standard acid to a pH of 4.0. Total alkalinity is expressed as milligrams per liter calcium carbonate, but is actually a determination of the buffering capacity of the liquid due to a number of weak acid species (i.e., carbonate, sulfite, borate, arsenite, selenite, and silicate). Precision is about 5%, and accuracy is estimated to be about 25%.

Total Conductance Determination

This measurement, which was made with a General Radio impedance bridge, Type 1650A, gave an estimate of the total ionic species in the sample. Precision is about 1%, and accuracy is estimated to be about 2%.

pH Determination

This parameter was measured with a Beckman Model 4500 digital pH meter to a precision of 0.005 pH units and an accuracy of 0.01 pH units.

Analytical Methods Applicable to Waste Solids

Waste solids were analyzed for calcium, sulfate, sulfite, and carbonate in addition to total solids and inert material (fly ash).

Total calcium was determined by atomic absorption spectrophotometry after the sample had been dissolved in hydrochloric acid.

Sulfate was determined gravimetrically, taking a 0.25-gram sample which was dissolved in hydrochloric acid. The solution was filtered, and barium chloride was added to the hot filtrate to precipitate barium sulfate. This was filtered off through a tared Gooch crucible with a glass filter pad. It was then dried and ignited at 800°C, cooled, and weighed.

Sulfite was determined volumetrically. A 0.5-gram sample was carefully acidified, using phenolphthalein indicator, then titrated directly with standard iodine using starch indicator.

Carbonate was determined by a gravimetric method, after evolution as CO_2, along with SO_2, by acidifying a 0.5-gram sample in a tared flask. The flask was warmed gently to expel all gases, cooled, and weighed. The weight decrease represents $CO_2 + SO_2$ and must be corrected for the SO_2 content determined by iodometric titration.

E.2 TESTING METHODS USED TO DETERMINE PHYSICAL CHARACTERISTICS OF TREATED WASTE

The physical testing of waste material is patterned after the American Society for Testing Materials (ASTM) standards as indicated.

Deviations from the recommended procedures, which are described below, occurred because of the dissimilarities of the waste material and soil properties to which the ASTM standards directly apply.

E.2.1 Unconfined Compressive Strengths

Rectangular samples were cut from the interior of the Shelby-tube waste cores for unconfined compressive strength measurements (in accordance with ASTM Designation D 2166-66, "Standard Methods of Test for Unconfined Compressive Strength of Cohesive Soil"). Typically, the samples were about 1 in.^2 in a cross-sectional area and about 2 in. in height. After measurement of dimensions, the samples were weighed and placed in a vacuum oven at approximately 60°C for drying to constant weight. Compressive strengths were measured on the unconfined samples, both in the as-received conditions of the cores and after drying, using an Instron testing machine to apply a compressive load at a constant rate of 0.02 in./min. Unconfined compressive strength is taken as the maximum load attained per unit area. The applied loads were recorded continuously until structural failures were obtained.

E.2.2 Modified California Bearing Ratio (Load-Bearing Strength)

Load-bearing strengths were measured for waste core samples, using a method substantively similar to the standard bearing ratio test for compacted soils (ASTM Designation D 1883-73). A 0.95-cm-diam (3/8-in.) rod was forced into the waste core samples at a constant rate of 0.25 cm/min (0.1 in./min) with an Instron loading machine. Penetration loads were recorded continously to a maximum penetration depth of 2.54 cm (1 in.). The cylindrical core sample container was sufficiently large, 7-cm (2.7-in.) diam by 10-cm (4-in.) depth, that edge and bottom effects were negligible. Tests were also made with 1.27-cm (0.5-in). and 2.54-cm (1-in.) diam rods which produced the same load-penetration curves for all three rods and confirmed that rod size was not a variable in these measurements.

E.2.3 Ultimate Bearing Capacity

Ultimate bearing capacity is a field measurement taken with a penetrometer (Soiltest, Inc., Model CN-988), using a No. 1 probe having a cross-sectional area of 0.33 in^2. With a maximum depth range of 6 in., the penetrometer is manually pushed into the waste material, and the maximum load per unit area that can be reacted by the material is taken as the ultimate bearing capacity.

E.2.4 Permeability

Constant head permeability tests (for example, ASTM Designation D 2434-68, "Standard Method of Test for Permeability of Granular Soils - Constant Head") and leaching tests were made on monolithic samples of 4 to 6 in. in height. Five-in.-diam sections of treated waste taken from the coring tube were sealed with silicone elastomer in plastic tubes. After addition of a 6-in. column of water above the waste, the tubes were pressurized with nitrogen to 5 psi to accelerate the tests if necessary. The rate of permeation was measured and converted to permeability coefficients, and leachate samples were collected periodically. The pH and TDS were measured immediately, and analyses for the major constituents were made according to the procedures described under chemical analyses.

E.2.5 Wet Bulk Density, Percent Solids

Samples were cut from Shelby-tube cores to about 1 in^2 in a cross-sectioned area about 2 in. in height. After measurement of dimensions, the samples were weighed and placed in a vacuum oven at approximately 60°C for drying to constant weight. The wet-bulk density was taken as the material weight divided by the volume in the as-received condition; percent solids were taken as weight of the material minus the weight of the water (found by drying the sample), divided by the weight of the material in the as-received condition.

E.3 TESTING PROCEDURES FOR SOIL ANALYSIS

Approximately 100 grams of each sample were freeze-dried to constant weight and finely ground in a porcelain ball mill.

E.3.1 Sulfate and Chloride Analysis

An accurately weighed portion of about 10 grams of the freeze-dried powder was leached by 100 ml of boiling distilled water for one hour. The resultant suspension was flocculated with KH_2PO_4 and filtered through Whatman GF/F glass fiber filters. One-half of the leachate was titrated with $AgNO_3$ for chloride, and one-half was precipitated with $BaSO_4$ for sulfate. Both Cl and SO_4 were near the limit of detection in most of the samples.

E.3.2 Elemental Analysis

An accurately weighed portion of about 5 grams of the freeze-dried power was leached for one hour with boiling concentrated nitric acid. The acid was evaporated to near dryness, and the sample was washed through Whatman 52 filter paper with 1N nitric acid. The volume was adjusted to 50 ml, and Fe, Ca, Cd, As, Se, and Pb were determined by atomic absorption spectrometry. As and Pb were determined by flameless AA (HGA-2100), whereas Fe, Ca, and Cd were determined in the flame.

Mercury was determined in an aliquot of the wet sediment so as to avoid possible loss during freeze-drying and was leached with concentrated HNO_3 and $KMnO_4$ in vessels with air condensers to avoid loss during digestion. Concentrations were converted to dry weight using the water content data after the cold vapor AA determination.

APPENDIX F

SUPPORT CALCULATIONS FOR WATER REUSE IN AN UNDERDRAIN DISPOSAL SITE

The data and calculations used in Section 5.3, Water Reuse in an Underdrain Disposal Site, are provided and include:

F.1 Climatological Conditions at Paducah, Kentucky, 1978

F.2 Evaporation Estimates from a Nondrained Site

F.3 Pond Size Requirements

F.4 Coal Chloride Content

F.5 Evaporation Estimates from an Underdrained Site

F.6 Site H (Gypsum) Filling Water Balance

F.7 Compression Effects of Construction Activities

F.8 References

F.1 CLIMATOLOGICAL CONDITIONS AT PADUCAH, KENTUCKY, 1978

Climatological conditions which are necessary for evaporation calculations (Sections F.2 and F.5) are given in Table F-1 for Paducah, Kentucky, for the year 1978. Rainfall in the Paducah area averages approximately 48 in./yr. The total amount of water applied to a 50-arce site by rainfall is:

$$(48\ \text{in./yr}) \times (1\ \text{ft}/12\ \text{in.}) \times (50\ \text{acres}) \times (43560\ \text{ft}^2/\text{acre}) \times (7.48\ \text{gal/ft}^3)$$

$$\times (1\ \text{yr}/365\ \text{days}) \times (1\ \text{day}/1440\ \text{min}) = 124\ \text{gpm}$$

F.2 EVAPORATION ESTIMATES FROM A NONDRAINED SITE

Using the method described below, the yearly evaporation loss from a nondrained 50-acre pond is estimated at 43.4 in./yr or 112 gpm.

Since a nondrained pond is analogous to a shallow lake, evaporative losses may be calculated using solar radiation, wind velocity, mean air temperature, and dew point temperature from a method for estimating evaporation from shallow lakes (Ref. F-1). Temperatures and humidity are found on a monthly basis by averaging daily Shawnee data. Recorded daily is the average humidity over the month (average monthly weather data are summarized in Section F.1). Wind movement is assumed constant at the average yearly velocity.

TABLE F-1. MONTHLY AVERAGE TEMPERATURE AND HUMIDITY, PADUCAH, KENTUCKY, 1978

MONTH	TEMPERATURE		RELATIVE HUMIDITY %
	°F	°C	
JANUARY	22	-5.6	75
FEBRUARY	20	-6.7	70
MARCH	41	+ 5.0	75
APRIL	58	14.4	60
MAY	64	17.8	75
JUNE	75	23.9	69
JULY	79	26.1	82
AUGUST	75	23.9	83
SEPTEMBER	60	15.6	86
OCTOBER	54	12.2	69
NOVEMBER	51	10.6	82
DECEMBER	37	2.8	85

[a] AVERAGED FROM THE ARITHMETIC MEAN OF THE MAXIMUM AND MINIMUM DAILY TEMPERATURES FROM SHAWNEE WEATHER DATA.

The dew point temperature is found from air temperature and relative humidity from the following equation (Ref. F-1):

$$f = \frac{112 - 0.1\ T + T_d}{112 + 0.9\ T}^{8}$$

where

f = Relative humidity

T = Average air temperature, °C

T_d = Dew point temrerature, °C

Solving the equation for T_d:

$$T_d = f^{1/8}(112 + 0.9\ T) - 112 + 0.1\ T$$

Monthly dew point temperatures are given in Table F-2.

Solar radiation values are estimated from maxima and minima radiation data (Ref. F-2) and calculated as follows:

$$S_R = S_{Rmin} + \frac{n}{N}\,(S_{Rmax} - S_{Rmin})$$

where

S_R = Design solar radiation,Langley/day

S_{Rmin} = Minimum solar radiation at 35°N latitude on a monthly basis, Ly/day

S_{Rmax} = Maximum solar radiation at 35°N latitude, Ly/day

$\frac{n}{N}$ = Fraction of sunny days over the time interval of interest (ranges from 0.55 to 0.75)

Monthly solar radiation values are given in Table F-2.

The shallow-lake evaporation can be plotted in a nomograph as a function of solar radiation air temperature, dew point and wind movement (see page 161, Ref. F-1). The input data used and the evaporation estimate are summarized in Table F-2. From these monthly values, the yearly evaporation loss from a nondrained pond is calculated to be 43.4 in./yr or 112 gpm for a 50-acre pond.

TABLE F-2. SHALLOW-LAKE EVAPORATION ESTIMATES

MONTH	SOLAR RADIATION LANGLEYS/DAY	AIR TEMP. ^{o}F	DEW POINT TEMP. ^{o}F	WIND MOVEMENT MILES/DAY	EVAPORATION INCHES/DAY	EVAPORATION INCHES/MONTH
JANUARY	255	22	15.1	40	0.025	0.775
FEBRUARY	338	20	11.6	40	0.026	0.728
MARCH	465	41	33.6	40	0.08	2.48
APRIL	580	58	44.0	40	0.16	4.80
MAY	665	64	55.9	40	0.19	5.89
JUNE	695	75	64.1	40	0.22	6.6
JULY	690	79	73.0	40	0.23	7.13
AUGUST	630	75	69.5	40	0.17	5.27
SEPTEMBER	530	60	55.8	40	0.14	4.20
OCTOBER	400	54	43.9	40	0.115	3.57
NOVEMBER	297	51	45.7	40	0.04	1.20
DECEMBER	233	37	32.9	40	0.025	0.775

F.3 POND SIZE REQUIREMENTS

The pond size requirements for a 1000-MWe scrubber system considering different solids content in the FGD waste are summarized below. An example calculation for various cases identified below is given in Figure F-1.

Waste Type	Underdrainage	Solids, wt %	Density, g/cm^3	Water Retained at Site, gpm	Disposal Area, acres/yr
Lime/ Limestone	No	45	1.5	510	26.6
Lime/ Limestone	Yes	55	1.5	341	21.7
Lime/ Limestone	Yes	60	1.5	278	19.9
Gypsum	Yes	74	1.7	147	14.3
Gypsum	Yes	80	1.7	104	13.2

F.4 COAL CHLORIDE CONTENT

An average chloride content for coal based on a 21.1 lb/min flow rate of chloride in the flue gas is calculated as follows:

Assuming - power plant heat rate: 9000 Btu/kWh
- coal heat content: 12,000 Btu/lb
- 1000 MW_e power plant

Then,

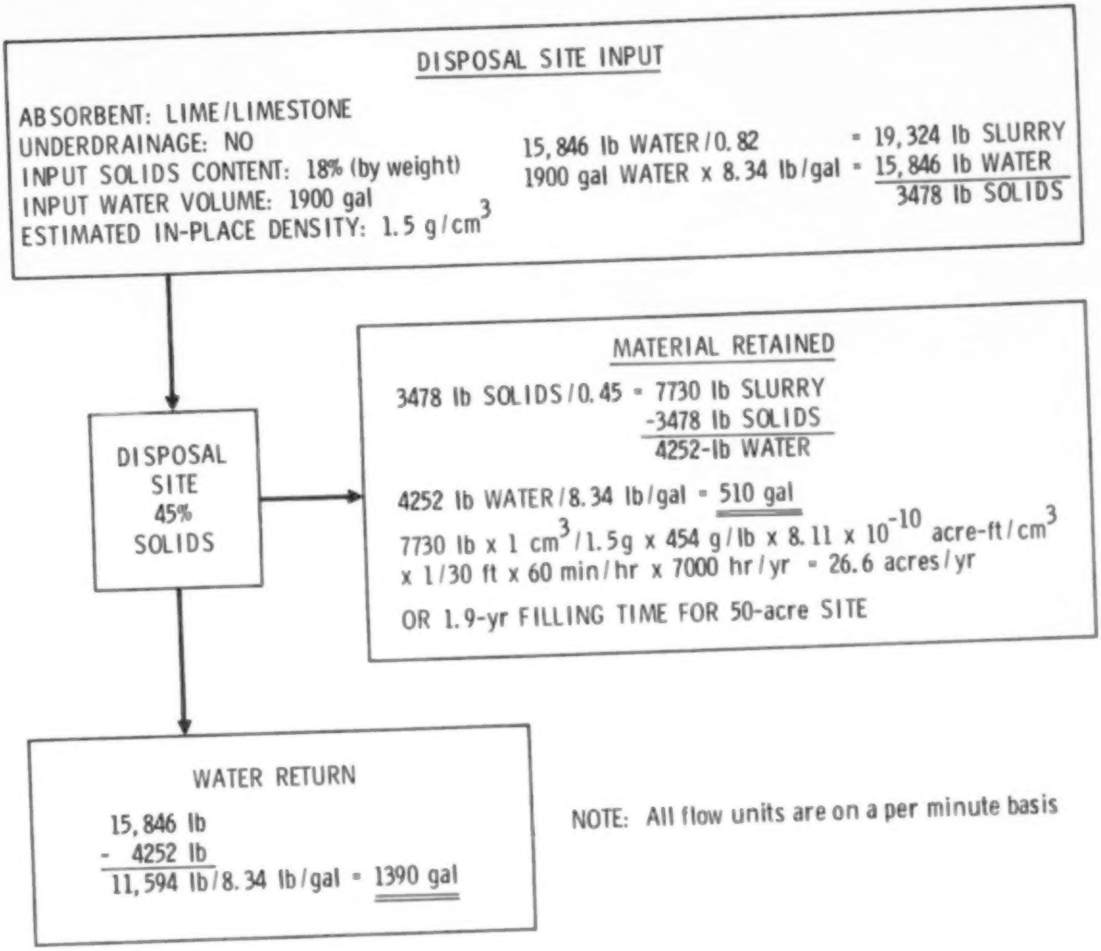
$$[(9000 \text{ Btu/kWh}) \times (1 \times 10^6 \text{ kW})] \div [(12000 \text{ Btu/lb}) \times (60 \text{ min/hr})] =$$

$$1.25 \times 10^4 \text{ lb/min coal}$$

$$[(21.1 \text{ lb/min}) \div (1.25 \times 10^4 \text{ lb/min})] \times (100) = 0.17\% \text{ Cl}^-$$

F.5 EVAPORATION ESTIMATES FROM AN UNDERDRAINED SITE

Evaporation losses from an underdrained site will be different from that of a shallow lake described in Section F.2. Portions of the site that are allowed to settle, while other areas are being filled, may show evaporation similar to a soil surface. The areas being filled would probably show a


DISPOSAL SITE INPUT
ABSORBENT: LIME/LIMESTONE
UNDERDRAINAGE: NO
INPUT SOLIDS CONTENT: 18% (by weight)
INPUT WATER VOLUME: 1900 gal
ESTIMATED IN-PLACE DENSITY: 1.5 g/cm³
15,846 lb WATER/0.82 = 19,324 lb SLURRY
1900 gal WATER x 8.34 lb/gal = 15,846 lb WATER
3478 lb SOLIDS
DISPOSAL SITE 45% SOLIDS
MATERIAL RETAINED
3478 lb SOLIDS/0.45 = 7730 lb SLURRY
-3478 lb SOLIDS
4252-lb WATER
4252 lb WATER/8.34 lb/gal = 510 gal
7730 lb x 1 cm³/1.5g x 454 g/lb x 8.11 x 10⁻¹⁰ acre-ft/cm³ x 1/30 ft x 60 min/hr x 7000 hr/yr = 26.6 acres/yr
OR 1.9-yr FILLING TIME FOR 50-acre SITE
WATER RETURN
15,846 lb
- 4252 lb
11,594 lb/8.34 lb/gal = 1390 gal

NOTE: All flow units are on a per minute basis

Figure F-1. Water balance for base case return calculation disposal site with 45% solids content somewhat greater evaporation rate due to the turbulence of pouring waste and the slight elevated temperature. Evapotranspiration, which is somewhat greater than evaporation from an undisturbed soil mass, was chosen as an estimate for evaporation from an underdrain system. The methods used give an average evaporation rate of about 77 gpm for a 50-acre site.

Water losses from evaporation can be calculated with climatological data in a method similar to the one used in Section F.2. The Penman and Thornwaite methods can be used to estimate evapotranspiration using solar radiation and temperature as the variables.

Penman's equation for evapotranspiration (Ref. F-3) is:

$$E_T = \frac{\Delta(H) + 0.27\ (E_A)}{\Delta + 0.27}$$

with

$$H = R_A(1 - r)\ (0.18 + 0.55\ n/N) -$$

$$\left[\sigma T_a^4\ (0.56 - 0.092\sqrt{e_d})\ (0.10 + 0.90\ n/N)\right]$$

$$E_a = 0.35\ (e_a - e_d)\ (1 + 0.0098\ u_2)$$

where

E_T = evapotranspiration (mm H_2O/day)

H = daily heat budget at surface (mm H_2O/day)

E_a = evaporation (mm H_2O/day)

R_A = mean monthly extra terrestrial radiation (mm H_2O/day)

r = reflection coefficient of surface

n = actual duration of bright sunshine

N = maximum possible duration of bright sunshine

σ = Boltzmann constant

σT_a^4 = mm H_2O/day

e_d = saturation vapor pressure at mean dew point (mm Hg)

e_a = saturation vapor pressure at mean air temperature (mm Hg)

u_2 = mean windspeed at 2 meters above the ground (miles/day)

u_1 = measured windspeed (miles per day at height h in feet)

Δ = slope of saturated vapor pressure curve of air at absolute temperature T_a in °F (mm Hg/°F)

The values of each of these parameters can be estimated using the local temperature (given in Section F.1) by various tables and graphs provided in Ref. F-3 (pages 240-245). The value of each of the terms, given in Table F-3 are on a monthly basis, and the total evaportranspiration for one year is determined by summing the January to December monthly totals. Yearly evapotranspiration from the Penman method is equal to 31 in./yr or an equivalent of 79 gpm. The Thornthwaite method is similar to Penman's but makes simplifying assumptions. Thornthwaite uses an empirical formula based on temperature to find evaporation. Monthly temperatures are used to determine a seasonal heat index value:

$$i = \left(\frac{T}{5}\right)^{1.514}$$

where

i = heat index

T = temperature (°C)

A nomograph (Ref. F-3, page 246) is used to relate the heat index to a monthly evapotranspiration potential. This potential use is corrected for sunlight and days of the month from a table provided based on the station latitude. Thus:

$$E_T = (E)\ (F_c)$$

where

E = evaporation potential (cm H_2O)

F_c = correction factor

E_T = evapotranspiration estimate (cm H_2O)

The values for the Thornthwaite calculation are given in Table F-4. A value of E_T equal to 29 in./yr or roughly 75 gpm is obtained, which agrees well with the Penman method.

F.6 SITE H (GYPSUM) FILLING WATER BALANCE

The calculation of water balance for site H is based on data collected during filling shown in Table F-5. The input water was calculated from the amount of gypsum waste poured, the percent solids in the gypsum, and the addition of rainfall to the site. Note that one inch of rainfall collected on the surface of Site H is approximately equal to 1000 gal (40 ft × 40 ft × 1 ft/12 in. × 7.48 gal/ft^3) = 997 gal.

TABLE F-3. DATA FOR SOLVING PENMAN EQUATION

Month	n/N	u_2[b]	R_A	e_a	r	e_d	σT_a^4	H	E_A	Δ	E_T	E_T Monthly Total
Jan	.60	40	7.25	-	.25	-	2	-	-	0.1	-	0
Feb	.60	40	9.40	-	.25	-	2	-	-	0.1	-	0
Mar	.70	40	11.85	5	.25	3.75	11.99	0.67	0.61	0.25	0.64	19.84
Apr	.75	40	14.35	14	.25	8.4	13.76	3.26	2.73	0.44	3.06	91.8
May	.75	40	15.95	17.5	.25	13.13	14.45	4.55	2.13	0.50	3.70	114.7
Jun	.75	40	16.60	23	.25	15.84	15.65	5.04	3.47	0.76	4.63	138.9
Jul	.75	40	16.25	27	.25	22.14	16.13	5.63	2.37	0.80	4.81	149.1
Aug	.75	40	15.85	23	.25	19.09	15.65	5.12	1.91	0.76	4.28	132.7
Sept	.75	40	12.85	15	.25	12.90	13.96	3.22	1.02	0.46	2.73	81.9
Oct	.70	40	10.30	10	.25	6.90	13.82	1.15	1.51	0.45	1.29	39.9
Nov	.65	40	7.90	8	.25	6.56	13.04	0.29	.70	0.34	0.47	14.6
Dec	.55	40	6.70	3	.25	2.99	11.67	-	.01	0.20	0.02	0.05
											Yearly total:	783 mm

[a] Note: Units and definitions are given in text.
Solar radiation is for 35°N latitude.
Reflection coefficient estimated at 0.25

[b] Wind measurements taken at other heights can be corrected to the 2-meter elevation by: $u_2 = u_1$ (log 6.6/log h)

TABLE F-4. DATA FOR SOLVING THORNTHWAITE EQUATION

Month	Heat Index (i)	Evap. Potential (E)	Correction Factor (f_c)	Evapotrans. (E_T)
Jan	-	-	-	-
Feb	-	-	-	-
Mar	1.00	1.3	1.03	1.34
Apr	4.96	5.3	1.09	5.78
May	6.84	7.0	1.21	8.47
June	10.68	12.5	1.21	13.72
July	12.21	13.8	1.23	16.97
Aug.	10.68	12.5	1.16	14.50
Sept.	5.60	5.4	1.03	5.56
Oct.	3.86	4.0	0.97	3.88
Nov.	3.12	3.0	0.86	3.01
Dec.	0.42	0.6	0.85	0.48
			Total	73.7 cm/yr

TABLE F-5. SITE H FILLING DATA

Date	Time	Truck #	Clarifier Solids %	Waste Level (in.)	Waste Poured (gal.)	Cumulative Waste Poured (gal.)	Underdrain Meter[a] (gal.)	Pumped Per Previous 24 Hours (gal.)	Remarks
8-19-77	0740	1	36.6	3 1/2	1680	1680	1800	-	Pumping clarifier underflow at 4 GPM.
8-19-77	0810	2	31.4	7"	1680	3360	-	-	
8-19-77	1415	1	39.8/ 30.6	9"	1680	5040	3200(B.F.)	-	
8-20-77	0720	1	34.9/ 32.7	0"(B.F.)	1680	6720	4330(B.F.)	2530 -	Underdrain overflowed overnight (4' depth) Collection tank 28" dia x 32" deep. Float valve rod lubed; water pumped out
8-20-77	0740	2	26.1/ 29.3	9"	1680	8400	-		
8-20-77	1400	1	22.4/ 32.5	16"(A.F.)	1680	10,080	5457(B.F.)	-	
8-21-77	0735	1	37.9/ 42.4	9"(B.F.)	1680	11,760	7700(B.F.)	3370 -	
8-21-77	0825	2	42.4/ 34.6	18"(A.F.)	1680	13,440	7800(A.F.)	-	
8-21-77	1315	1	34.4/ 54.9	21"(A.F.)	1680	15,120	8140(B.F.)	-	
8-22-77	0740	1	41.3	16"(B.F.) 23"(A.F.)	1680	16,800	9715(B.F.)	2015 -	
8-22-77	0815	2	35.9	23"(B.F.)	1680	18,480	9810(A.F.)	-	
8-22-77	1415	1	29.7/ 37.5	26"(A.F.)	1680	20,160	10,325(A.F.)	-	

[a] Note. B.F. - Before Filling
A.F. - After Filling

TABLE F-5. SITE H FILLING DATA (Continued)

Date	Time	Truck #	Clarifier Solids %	Waste Level (in.)	Waste Poured (gal.)	Cumulative Waste Poured (gal.)	Under-drain Meter (gal.)	Water Pumped Per Previous 24 Hours (gal.)	Remarks
8-23-77	0735	1	27.8/ 36.7	22"(B.F.)	1680	21,840	11,885(B.F.)	2170	
8-23-77	0750	2	36.7/ 28.3	——	1680	23,520	11,925(A.F.)	-	
8-23-77	1410	1	33.4	30"(A.F.)	1680	25,200	12,520(A.F.)	-	
8-24-77	0750	1	34.4	22"(B.F.)	1680	26,880	14,290(B.F.)	2405	
8-24-77	0815	2	34.3	32"(A.F.)	1680	28,560	-		
8-24-77	1410	1	27.5	33"(A.F.)	1680	30,240	14,947(B.F.)	-	
8-25-77	0745	1	36.6	24.0"	1680	31,920	16,832(B.F.)	2542	
8-25-77	0810	2	40.9	35.0"	1680	33,600	16,930(A.F.)	-	
8-26-77	0720	1	19.7	27"(B.F.)	1680	35,280	19,510	2678	
8-26-77	0805	2	15.5	36"(A.F.)	1680	36,960	19,626	-	
8-26-77	1415	3	26.5	36"(A.F.)	1680	38,640	20,350		
8-27-77	0720	1	39.1	31.5"(B.F.)	1680	40,320	22,404	2894	
8-27-77	0745	2	41.6	37.5"(A.F.)	1680	42,000	22,500	-	
8-27-77	1410	3	29.6	38.5"(A.F.)	1680	43,680	23,350	-	
8-28-77	0710	1	35.1	33.5"(B.F.)	1680	45,360	25,710	3306	
8-28-77	0745	2	24.1	39"(A.F.)	1680	47,040	25,800	-	
8-28-77	1405	3	39.2	40"(A.F.)	1680	48,720	26,662	-	Rained (trace)

TABLE F-5. SITE H FILLING DATA (Continued)

Date	Time	Truck #	Clarifier Solids %	Waste Level (in.)	Waste Poured (gal.)	Cumulative Waste Poured (gal.)	Underdrain Meter (gal.)	Water Pumped Per Previous 24 Hours (gal.)	Remarks
8-29-77	0730	1	39.4	35.5"(B. F.)	1680	50,400	29,100	3390	Raining all day, totalling 0.675 inches
8-29-77	0805	2	30.0	41"(A. F.)	1680	52,080	29,200		
8-29-77	1415	3	28.3	42"(A. F.)	1680	53,760	30,010		
8-30-77	0720	1	33.5	38"(B. F.)	1680	55,440	32,304	3204	Rained 0.05 inches
8-30-77	0745	2	35.4	43"(A. F.)	1680	57,120	32,375		
8-30-77	1410	3	30.2	42"(A. F.)	1680	58,800	-		
8-31-77	0725	1	27.3	42"(B. F.)	1680	60,480	35,500	3196	
8-31-77	0800	2	38.0	45"(A. F.)	1680	62,160	35,653		
8-31-77	1415	3	31.2	45"(A. F.)	1680	63,840	36,500		
9-1-77	0720	1	29.9	46"(B. F.)	1680	65,520	38,664	3164	
9-1-77	0750	2	36.6	46"(A. F.)	1680	67,200	38,770		
9-1-77	1420	3	34.2	47"(A. F.)	1680	68,880	39,700		
9-2-77	0725	1	35.1	44"(B. F.)	1680	70,560	41,930	3266	
9-2-77	0755	2	36.5	47"(A. F.)	1680	72,240	42,037		
9-15-77	-	-	-	-	-	72,240	45,474	3544	Cumulative rainfall for 9/3 through 9/15 = 10"
9-26-77	-	-	-	-	-	72,240	48,085	2611	Cumulative rainfall for 9/16 through 9/26 = 24"

The average cumulative percent solids during filling of clarifier underflow was 74% with a subsequent increase in solids to 80% four days after filling was completed. There were only minor variations in this solids content during the ensuring month which included the addition of filter cake to the surface of the site. The calculation of solids content, shown in Table F-6, was based on the following:

Water input = (1 - waste solids content) × (waste poured)

Solids input = waste poured - water input

Net water = water input + rainfall - underdrain meter

$$\text{Solids content} = 1 - \frac{\text{net water}}{\text{net water + solids input}}$$

F.7 COMPARISON EFFECTS OF CONSTRUCTION ACTIVITIES

The pressure exerted by a tractor or other ground moving equipment in closing a site can be estimated. A pressure of 70 psi at the surface will exert a pressure of 1.4 psi at a 10-ft depth and nearly zero at 20 ft.

The unit pressure at a point in the under-soil can be calculated by integrating the Boussinesq formula for the case of loads uniformly distributed over a rectangular area (Ref. F-4). The resulting equation for the unit pressure at a point at depth H directly under one corner of a loaded rectangle of dimensions A and B is

$$\frac{\sigma_z}{P} = \frac{1}{4\pi}\Big[\frac{2\ ABH\sqrt{A^2 + B^2 + H^2}}{H^2(A^2 + B^2 + H^2) + A^2B^2} \times \frac{A^2 + B^2 + 2H^2}{A^2 + B^2 + H}$$

$$+ \Big(\mathrm{Sin}^{-1}\ \frac{2\ ABH\sqrt{A^2 + B^2 + H^2}}{H^2(A^2 + B^2 + H^2) + A^2B^2}\Big)\Big]$$

where

σ_z = unit pressure at depth H

P = unit load applied over rectangular area A by B

The results, shown below, are estimated for a 2-ft^2 tire pad (which yields a total pad area of 4 ft^2) and a load of 70 psi:

Depth, ft	Resulting psi Directly Underneath
5	5
10	1.4
15	0.5
20	~0

TABLE F-6. SITE H FILLING WATER BALANCE

	Date	Cumulative Solids	Cumulative Input		Output Meters	Net Water Remaining	Cumulative % Solids
			Waste Water	Rainfall			
Clarifier Underflow Filling	Aug 19	1734	3306	1800	4330	776	69.1
	20	3228	6852	1800	7700	952	77.2
	21	5300	9820	1800	9715	1905	73.6
	22	7162	12999	1800	11885	2913	71.1
	23	8810	16390	1800	14290	3900	69.3
	24	10426	19813	1800	16832	4852	68.2
	25	11728	21872	1870	19510	4232	73.5
	26	12765	25875	1870	22404	5341	70.5
	27	14618	29062	1870	25710	5222	73.6
	28	16271	32449	1870	29100	5219	75.7
	29	17912	35848	2545	32304	6089	74.6
	30	19577	39223	2595	35500	6318	75.6
	31	21198	42642	2595	38664	6573	76.3
	1	22890	45990	2595	41930	6655	77.5
	2	24093	48147	2595	42037	8705	73.5
	3	-	-	-	-	-	-
	4	-	-	-	-	-	-
	5	-	-	-	-	-	-
	6	24093	48147	2595	44720	6022	80.0
	7	24093	48147	2595	44720	6022	80.0
	8	-	-	-	-	-	-
	9	-	-	-	-	-	-

TABLE F-6. SITE H FILLING WATER BALANCE (Continued)

	Date	Cumulative Solids	Cumulative Input		Output Meters	Net Water Remaining	Cumulative % Solids
			Waste Water	Rainfall			
	10	-	-	-	-	-	-
	11	-	-	-	-	-	-
	12	24093	48147	2625	44724	6048	79.9
	13	24093	48147	2625	44726	6048	79.9
	14	24093	48147	3385	44973	6559	78.6
	15	24093	48147	3725	45474	6398	79.0
	16	-	-	-	-	-	-
	17	-	-	-	-	-	-
	18	-	-	-	-	-	-
	19	-	-	-	-	-	-
Filter Cake Filling	20	-	-	-	-	-	-
	21	-	-	-	-	-	-
	22	-	-	-	-	-	-
	23	-	-	-	-	-	-
	24	-	-	-	-	-	-
	25	-	-	-	-	-	-
	26	24093	48147	6095	48085	6157	79.6
	27	-	-	-	-	-	-
	28	-	-	-	-	-	-

F.8 REFERENCES

F-1. R. K. Linsley, M. A. Kohler, J. L. Paulhus, Hydrology for Engineers, Second Edition, McGraw Hill Book Co., New York (1975).

F-2. Algae Research Project, Sanitary Engineer Research Laboratory, Dept. of Engineering, University of California, Berkeley, California (1954).

F-3. O. W. Iraelson and V. E. Hansen, Irrigation Principles and Practices, John Wiley & Sons, Inc., New York (1962).

F-4. M. G. Spangler, Soil Engineering, International Text Books (1951), p 228.

APPENDIX G

MISCELLANEOUS COST AND ANALYSES

The cost of land, the utility's capacity factor, and the cost of disposal pond liners as they affect FGD waste disposal costs were assessed. The results are given in the following paragraphs.

G.1 COST OF LAND

The cost of waste disposal land was reviewed in order to update cost estimates for this report. Estimates were obtained from eight sources, which were either power companies or government agencies cognizant of real estate values. Table G-1 is a summary of land costs, area of applicability, and points of contact.

It was learned that, for disposal purposes, land values differ substantially throughout the U.S. (from \$200 to \$40,000/acre); however, in most of the cases examined where the land has been acquired recently, utilities have not paid more than \$1000 to \$2000 per acre. In general, but not universally, urban area land costs are substantially more than rural, undeveloped, or reclaimed land. For example, in the area of Paducah, Kentucky, land suitable for waste disposal in rural and undeveloped areas (\$1000/acre) is approximately half as much as land near residential areas.

Showing the extremes involved, the municipal government of St. Louis, Missouri, has recently purchased a landfill area in a suburban section of the city for approximately \$40,000/acre. Although this price includes the cost of buying out the current landfill operators, the average price of land in the immediate area is between \$26,000 and \$39,000/acre.

Based on the information collected in this investigation, the average typical land cost used in cost estimates in this study is \$2,000/acre. Since wide variations exist depending on site-specific circumstances, the effect of land cost was determined as \$0.22/tonne of waste (dry).

It should also be noted that the value of reclaimed land was considered. In all cases examined, reclaimed land could probably be sold for the same price as surrounding land even though there were buiding restrictions imposed on the reclaimed land. This was the case for Paducah, Kentucky, St. Louis, Missouri, and Baldwin Hills, California. This information suggests that there may be a residual value attached to disposal land after its 30-year utility; however, it is difficult if not impossible to predict a specific value because of the uncertainty of the market over 30 years. Therefore, the residual value of land was not included in current cost estimates.

TABLE G-I. AVERAGE COST OF LAND AT SELECTED LOCATIONS IN THE U. S.

Location	Average Cost/Acre	Point of Contact, Company, Power Plant
Georgetown, SC	$1,000	Gene Chassereau, South Carolina Public Service Authority, Winyah 2
Hattiesburg, MS	$1,200-1,400	Roger Smith, R. D. Morrow, South MS Electric
Springfield, MO	$750-1,000	Springfield City Utilities, Southwest
Colstrip, MT	$200	Plant Engineer, Montana Power, Colstrip
Columbus, OH	$800-1,300	Roy Strawser, Columbus and Southern Ohio Electric, Conesville
Johnstown, PA	$600-1,000	Mr. Pasternak, Penelec
Paducah, KY	$1,000-2,000	Wayne Upshaw, City Engineer
Richmond, VA	$500 and up	Mr. Gilley, Environmental Council

G.2 GENERATING CAPACITY FACTOR

In previous costs estimates (Refs. G-1 through G-3), the 30-year average generating capacity factor* for a coal-fired power plant was calculated to be 48.5% based on Federal Power Commission (FPC) data. The 48.5% is derived as a weighted average of plant operating hours over the 30-year life. The initial years are typified by high utilization, and the remaining years are associated with decreased use as a peaking plant.

However, due to a nationwide trend towards increased productivity and utilization of resources, the average capacity factor is expected to increase as a function of time, demand, and technology. The increase that has already or is expected to take place will occur during the later years (16 to 30 years) of power plant opeation. This phase has been typically characterized by a low capacity factor, between 17 and 40%. The reasons for reduced capacity factors and utilizaton may be for a number of reasons including, technical constraints, increased required maintenance, construction of newer units, reduced demand, changes in plant utilization (i.e., switch from base-load to peaking facility), or any combination thereof.

Some recent data from FPC records of 30 supercritical coal-fired power plants between 422 MW and 1150 MW ranging from 2 years to 19 years old show capacity factors between 39 and 69%. Correlations between capacity factor and age can not be made since the plants are relatively new, some of the older plants are filling a high demand, and some of the new plants have a low demand or are experiencing startup problems. In any event, a statistical analysis of the data by Sandia Laboratories for the Nuclear Regulatory Commission (NRC) (Ref. G-4), indicates that at a 95% prediction interval, a 57% (±18%) capacity factor satisfactorily summarizes the data.

The Standard Handbook for Electrical Engineers (Ref. G-5) describes typical capacity factors for three types of plant utilization: (1) if a plant is utilized at base-load capacity, its typical annual capacity factor will be between 65 and 75%; (2) if utilized as an intermediate-load range capacity, its annual capacity factor will be in the 30 to 40 percent region; (3) and, if utilized as a peaking facility, the annual capacity factor will be between 5 and 15%.

Since the range of capacity factors for a base-load facility can be expected to be in the 57 to 75% range, 65% was considered as the value to be used for future cost estimates since it falls in the mid-range of the empircal data. This corresponds to 5694 operating hr/yr.

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*Capacity factor = [total annual generation in kWh] ÷ [maximum rating in kW × (8760 hr/yr)].

The effect of capacity factor on disposals of untreated FGD waste in an indigenous-clay lined pond is reported in Figure G-1 through G-3 on the basis on mills/kWh, \$/ton dry waste and \$/ton coal, respectively. For this type of disposal a cost reduction of approximately 8% results from an increase in the capacity factor from 48.5% to 65%.

G.3 COST ESTIMATE OF SYNTHETIC LINERS

Based on conversations with a DuPont technical representative regarding Hypalon and 3111 liners, the Hypalon industrial-grade liner (36 mils thick) is recommended over the 3111 and was used in this study as the basic material for purposes of estimating synthetic liner cost.

Industrial-grade Hypalon has better cross linkage between molecules than the 3111; undergoes less absorption and swell; and has a lower permeability, better temperature resistance, and better chemical resistance. However, some type of geotechnical preparation is required for the site, and the degree is dependent on site-specific characteristics.

The installed cost of Hypalon industrial-grade liner was estimated at between \$0.55/ft^2 to \$0.65/ft^2 (\$4.95/yd^2 to \$5.85/yd^2) for a site with side slopes of 2:1. Although the manufacturer recommends a maximum of 3:1, the slightly steeper side was used in the cost estimate as a practical approach to minimize land preparation and material requirements.

G.4 REFERENCES

G-1. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation; Initial Report, EPA-600/2-76-070, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (March 1976).

G-2. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation: Second Annual Report, EPA-600/7-78-024, U.S. Environmental Protection Agency, Research Triangle Park, NOrth Carolina (February 1978).

G-3. R. B. Fling, et al., Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation: Third Annual Report, EPA-600/7-80-011, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (January 1980).

G-4. Statistical Analysis of Power Plant Capacity Factors, NUREG/CR-0382, Sandia Laboratories, New Mexico (February 1979).

G-5. Fisk and Beaty, Standard Handbook for Electrical Engineers (1978), pp 12-18.

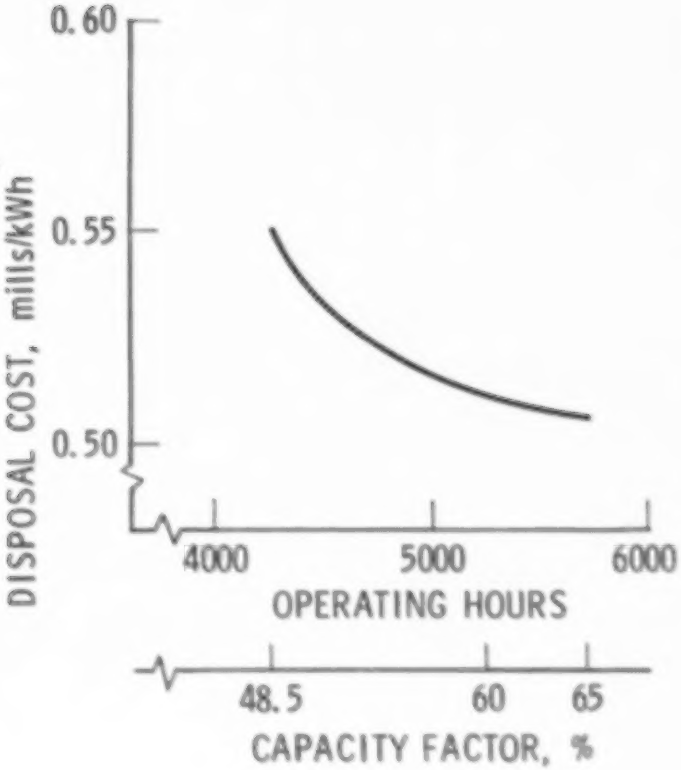

Figure G-1. Effects of capacity factor on FGD disposal cost (mills/kWh)

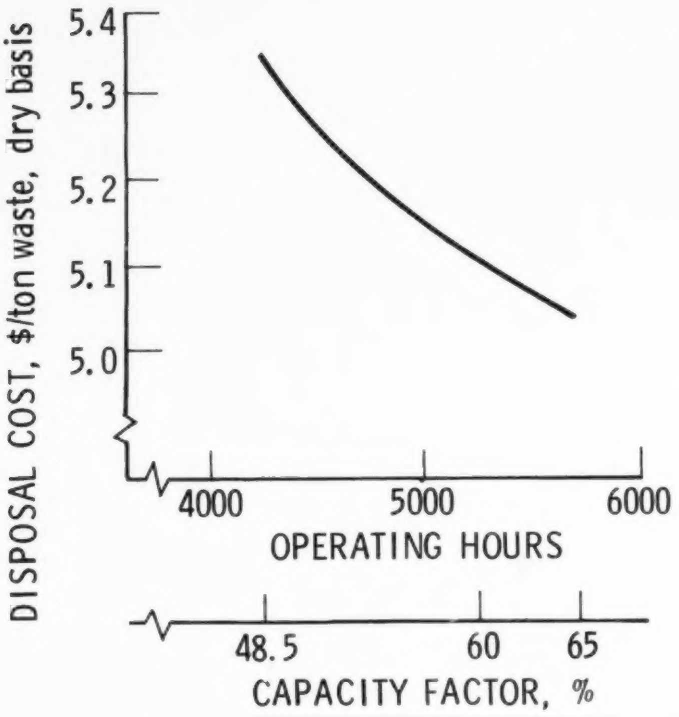

Figure G-2. Effects of Capacity factor on FGD disposal cost ($/tonne of waste)

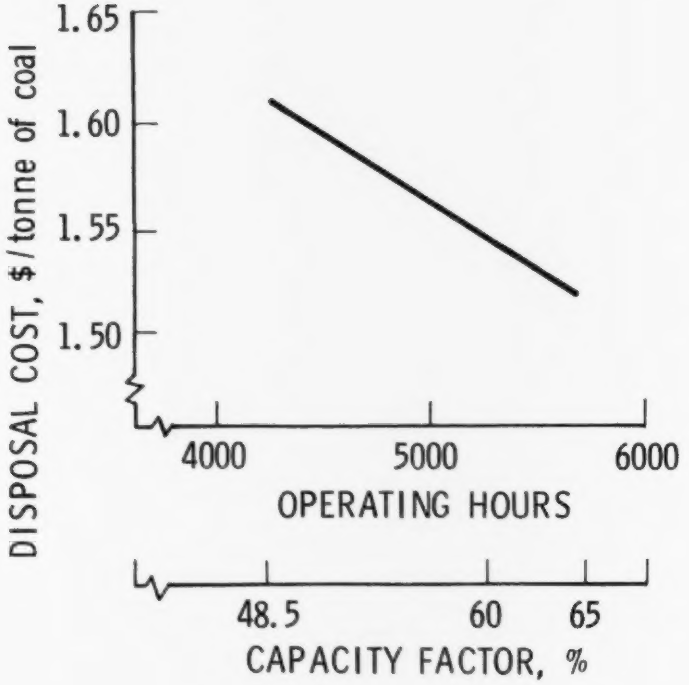

Figure G-3. Effects of capacity factor on FGD disposal cost ($/tonne of coal)